SCIENTIFIC AMERICAN

No. SUPPLEMENT 204

Scientific American Supplement, Vol. VII., No. 204. Scientific American, established 1845. NEW YORK, NOVEMBER 29, 1879. Scientific American Supplement, $5 a year. Scientific American and Supplement, $7 a year.

THE STEAMSHIP ORIENT.

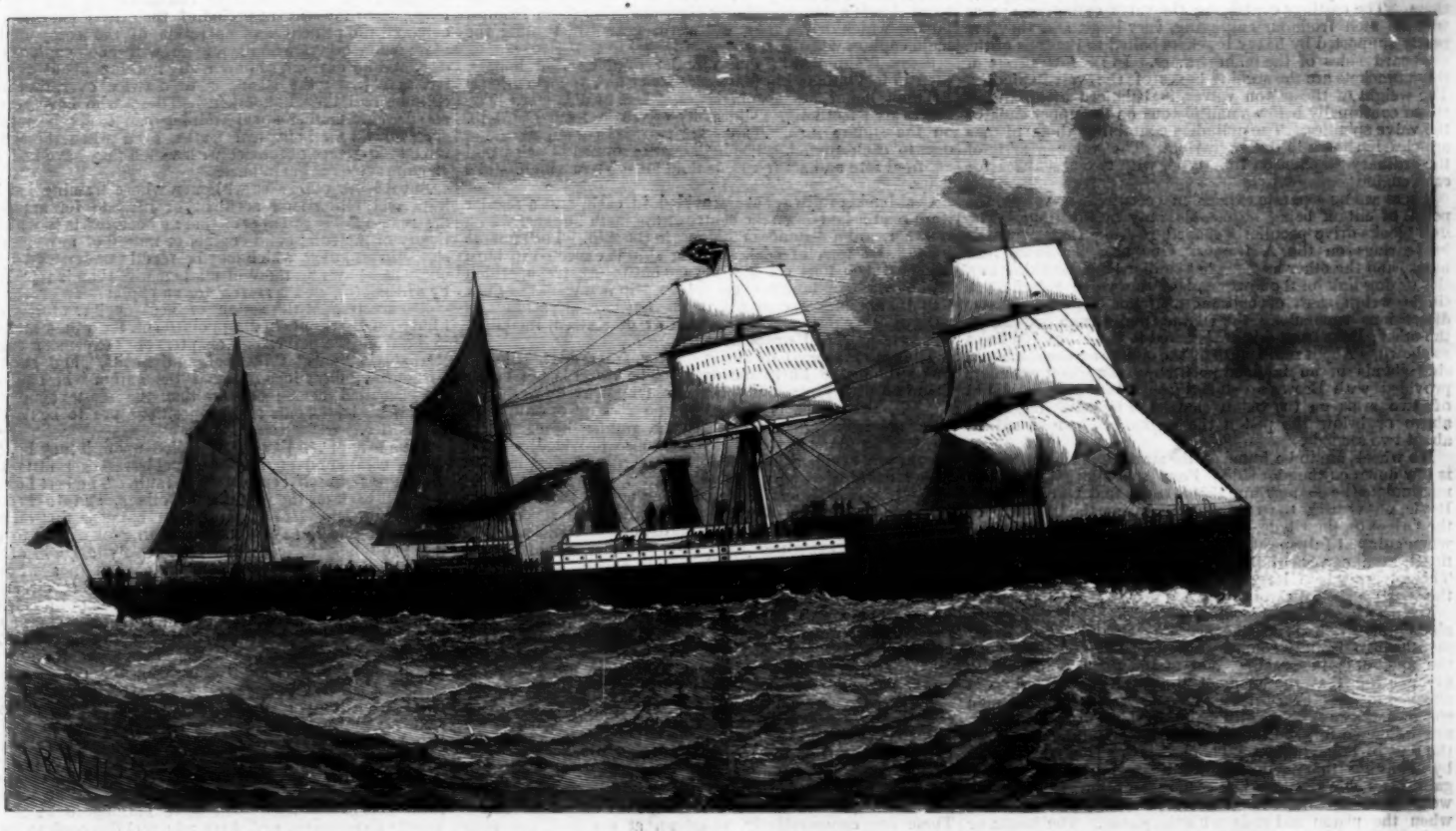
THIS magnificent new vessel arrived at the Southwest India Dock, London, from the Clyde, on the 13th Sept. She has been visited by thousands of people desiring to see the finest and best fitted ship, indeed the only full powered steamer expressly built and equipped for the Australian trade, and the grandest vessel for the conveyance of passengers that has ever appeared in the Thames. The Orient Steam Navigation Company, of which Messrs. F. Green & Co. and Messrs. Anderson, Anderson & Co. are joint managers, have arranged for a line of first class steamships to go out from London to Adelaide, Melbourne, and Sydney, steaming all the way in less than forty days, and to return by way of the Suez Canal. This is an entirely novel idea, as the Great Britain and other vessels, using steam, at least for auxiliary power, on the voyage out, have made the home voyage hitherto by the lengthened and inconvenient route of Cape Horn. The Orient is the first steamship that has been constructed expressly for the new service. She is, after the Great Eastern, which is said to roll too much for passengers' use, all but the largest of existing merchant steamships; only the Inman steamship City of Berlin, the Britannic and Germanic, of the White Star line, and the Arizona, of the Guion line, can in size at all bear comparison with her. The displacement weight of the Orient is 9,500 tons; her registered tonnage is 5,400 tons; her length is 460 ft.; her beam, 46·35 ft.; her depth to main deck, 27·1 ft.; to upper deck, 35·1 ft. When she takes her place on the service of the direct Orient line to Australia for which she has been built, the Orient will be prepared to carry, in addition to 3,000 tons of Welsh coal (more than sufficient to take her to Australia), 3,600 tons of measurement cargo, which might weigh 1,000 tons or so. She would also carry 120 first class passengers, 120 second class, and 300 third class or steerage passengers. By a sacrifice of cargo space she could carry 285 more third class passengers. A different arrangement of space would enable 1,500 troops and 400 horses to be carried in addition to the other passengers. If entirely devoted to troops, the ship could convey 3,000 men and 400 horses at once with the proper stores.

The Orient has been built for the new line of Australian steam navigation, which is named after her by Messrs. John Elder & Co., of Glasgow. The other vessels of this line are the Lusitania, the Cuzco, the Chimborazo, the Garonne, the Aconcagua, and the John Elder. One of these leaves London every four weeks, and one leaves Australia at the same time for the return passage. They take in the mails at Plymouth, carrying them without subsidy, and touch at St. Vincent and the Cape on their voyage out. The Orient is expected to make the passage in less time than her sister ships have done, but the Chimborazo lately came from Adelaide to Plymouth in thirty-seven days ten hours, including delay in the Suez Canal and stoppages for coaling. Her engines are of 5,400 horse power, and the average speed with which she ran the distance from Greenock to Margate was fourteen and a half knots, or more than fifteen miles an hour. The ship is bark rigged, with four masts, has three iron decks, and is divided into thirteen water-tight compartments, by bulkheads, while, as a security against fire, from the lower to the main deck, she is divided into six compartments by five fireproof bulkheads, fitted with fireproof doors. She had been equipped beyond the requirements of her class, 100 A1, the highest at Lloyds', and has satisfied Government inspection as regards her defense by means of water-tight compartments and coal bunkers, so that she would be available if requisitioned in time of war as a cruiser or troopship. Her coal bunkers are so placed as to protect her engines, while they carry coal enough to keep her at sea, steaming full speed, for forty days, and she could not be sunk by penetration of less than three of her water-tight compartments.

The engines, also made by Messrs. John Elder & Co., merit particular attention, having three cylinders instead of the common number of two; one is high pressure with 60 in. diameter, the others low pressure, 85 in. diameter. The crank shaft is built in separate pieces, shrunk together and keyed, the diameter of the shaft being 20 in., and that of the crank pins, which are of steel, 21 in. The propeller is four-bladed, the boss being of annealed cast iron and the blade of cast steel, specially made for the purpose by Messrs. Vickers, of Sheffield. The blades are bent backward to diminish vibration. The diameter of the screw is 22 ft., and the pitch 30 ft. The condenser contains nearly 12,000 square feet of cooling surface, and the water for condensation is circulated by means of two independent combined steam centrifugal pumps, made by Messrs. Gwynne & Co., of London. The condensing surface and the capacity of the centrifugal pumps are made larger than they otherwise would be because the temperature of the water on part of the voyage home—namely, in the Red Sea—is so high that an unusually large quantity of it is required to cool and so condense the steam. The reversing engine is a special feature. Moving a lever not only stops the engines when at full speed, but immediately turns them full speed astern, and this motion has been so simplified that Lady Gertrude Boyle, on visiting the engine room during the experimental cruise on the Clyde, easily stopped and reversed the engines when going at their maximum speed—that is to say, a young lady with one movement of her arm did what was tantamount to reining in 5,400 horses. The boilers are four in number, 15 ft. 6 in. diameter, by 17 ft. 6 in. long. They contain twenty-four furnaces, each 4 ft. diameter by 6 ft. long, and the working pressure is 75 lb. on the square inch. The furnaces are constructed with special arrangements for the economical consumption of Australian coal on the passage home. From the results obtained it has been definitely proved that the consumption of coal will be economical at the speed at which it is intended she should run. The engines worked very smoothly without priming on the trip. The special arrangements of the machinery are due to the ingenuity of Mr. A. D. Bryce, the able superintendent of this department for John Elder & Co.

A great feature of the first class accommodation is the splendid saloon forward, free from the engine room, free from berths, running through from side to side 44 feet square and very lofty. It is fitted with electro-plated brass furniture, carpeted with a pattern by William Morris, and opening into the music saloon above, where, amid ferns and dracænas growing as plentiful as in the Sunbeam, a piano and an organ are to be placed. Here are elaborate wood carvings and ornamentation in patterns of the English Renaissance of the nineteenth century. The third class accommodation supplies separate cabins with two berths for £18 per berth, and berths approached by separate passages for £15. The crew's forecastle is very spacious and comfortable. The chief saloon passengers have a promenade deck of 160 feet long, and the whole breadth of the vessel for their exclusive use, whilst the interior fittings of the dining saloons, music saloon, smoking rooms, and passengers' cabins are of an elegant description.

The vessel is fitted with patent hand and steam steering gear, steam windlass, five powerful steam winches, two condensers for supplying fresh water, four large life boats, and five other boats; punkahs worked by steam in the chief dining saloon, pneumatic bells to all saloon state rooms, speaking tubes and telegraphs. There are sixteen steam engines for different purposes in the ship. The arrangements for a constant and ample supply of fresh water are such as might suffice for a town. The large tanks fitted below the orlop deck in the after part of the ship hold about eighty tons. These are, of course, filled when the ship leaves the docks; but to keep up the supply required for daily use there are two large condensers which will condense, if required, 200 gallons per minute. The water when leaving the condenser enters a cooling tank fitted with a large spreader or aerator. From this tank it runs direct to the main tank, from which it is again pumped by a small steam pump in the engine room to a very large tank fitted on the promenade deck, whence it runs to every compartment into smaller tanks. Ice rooms are fitted on the lower deck for carrying sixty tons of ice. As a protection against fire, the sea can be admitted bodily into any two of the thirteen water tight compartments without sinking the ship. The protection against drowning is supplied by four life boats carrying eighty each; two cutters to convey ninety each, a gig and a mail boat calculated to sustain forty-five each; a large steam launch and twenty-six life rafts, each capable of saving from forty to sixty people. In every berth in every class is a life jacket which, rolled up, might be used as a bolster. Cattle enough to stock a farm are carried to provide fresh meat and milk on the voyage. A smaller ship



THE NEW STEAMSHIP ORIENT, OF THE ORIENT STEAM NAVIGATION COMPANY'S LINE, FOR AUSTRALIA.

of the line takes out six bullocks, one hundred sheep, three hundred dozen of poultry, and embarks twelve bullocks more at the Cape. Mosses' and Mitchell's automatic ventilators, used in the British and American navies, are fitted to all the lower decks of the ship. When scuppers are closed in stormy weather, these ventilators increase in activity and expel the foul air through gigantic cowls. A special ventilator of Mr. Shepherd's (marine superintendent to the Orient Company) keeps the first and second class cabins sweet.

The steamship Orient was, by the liberality of the Orient Steam Navigation Company, thrown open to inspection at moderate entrance charges, during three days of last week and on Monday last, for the benefit of five benevolent institutions—namely, the Dreadnought Seamen's Hospital, the East London Hospital for Children, the Poplar Hospital for Accidents, the Merchant Seamen's Orphan Asylum, and the Royal Alfred Merchant Seamen's Institution. The ship was thronged with visitors during the greater part of those days, and the sum of £873 was raised by this exhibition.—*Illustrated London News.*

THE STEAMSHIP ORIENT.

WE publish on next page an engraving from a photograph taken while the engines of the Orient stood in Messrs. John Elder & Co.'s erecting shop. This engraving gives as good an idea of their construction as it is perhaps possible to impart by drawings of any kind. We have already explained that they are of the three-cylinder type, with one 60 inch clyinder standing between two 85 inch cylinders, the stroke of all being 5 feet. The engines are, to a great extent, independent of each other, each cylinder being carried on its own A frames, no rigid connection existing between them save that supplied by certain heavy bolts with right and left handed screws, which, being set up when everything is hot, enable the necessary adjustments to be made. Similar bolts brace the engines to the coamings of the engine hatch in the deck. The cylinders are jacketed all over, and the top covers are very deep. Steam is taken into the jackets in these covers through three short branches on each cylinder.

Piston valves are fitted to all the cylinders instead of slide valves, the ports over which the pistons play being inclined at an angle to prevent the packing rings from getting into them. The castings containing the valve cylinders are, as will be seen from our engraving, very large, and they are partly supported by heavy brackets bolted to the tops of the starboard sides of the main frames. In the lower ends of these brackets are the stuffing boxes of the valve spindles. The weight of the piston valves is balanced by admitting steam continually below small pistons on the upper ends of the valve spindles. The cylinders containing these pistons are clearly shown in the engraving. The valve gear is of the ordinary Stephenson link type, with two eccentrics for each engine.

There are no separate expansion eccentrics or valves, the point of cut-off being adjustable only by the links. The link blocks drive peculiarly shaped rocking shafts turning in bearings on the A frames. One arm carries the link block, and the other a somewhat similar block working in a slot or dog link on the lower end of the valve spindle. A single weigh shaft of enormous, if not disproportionate, dimensions runs along the engine frames from one end to the other; links from this are secured to the expansion links as shown. About mid-length of the engine on the starboard side stands in an inclined position a long steam cylinder, provided with Brown's cataract gear. Side rods take hold of two arms on the weigh shaft, and by admitting steam above or below the piston the engine can be reversed in about two seconds.

No wheels are to be found on the starting platform, which is low down on the port side. Four small levers suffice to manipulate the engines, and this so easily that Lady Gertrude Boyle, on visiting the engine room during the trial trip of the Orient on the Clyde, stopped and reversed the engines when going at full speed. One of Durham's velometers is fitted in a corner of the engine room to prevent racing. This governor is of large size, and is driven by a rope from the shaft; a special throttle valve is provided for its use.

We may take this opportunity of stating that the favorable opinion we expressed concerning this governor many months ago is daily confirmed by the results obtained with the apparatus in practice, one of the great points in its favor being that the moment the speed of the engines is checked it gives them full steam again, and so the average speed of the engines is fully maintained. The piston rods are prolonged upward through very long stuffing boxes on the tops of the cylinders. There seems to be no doubt that by adopting this method of construction something is gained. The cylinders last longer, and the piston rings wear more equally, and give less trouble than is the case when the piston rod ends with the piston. The lower or main stuffing boxes are fitted with four nuts and bolts each, and the usual gear by which all four nuts can be turned at once.

The engines are very lofty, standing, indeed, not much less than 30 feet high, and a connecting rod nearly four cranks long has thus been obtained. This is a very important advantage. The longer the connecting rod the less the strain thrown on the guides, and the less the chance of their heating. Sea-going engineers know well how liable guides are to give trouble, and what incessant attention they require. The slide blocks of the engines of the Orient are cast open, and this tends to prevent the transmission of heat from the piston rod, as a current of air always passes through the block when it is in rapid motion. The wearing surfaces are very large, and much care has been taken to insure their efficient lubrication.

The crank shaft is 20 inches in diameter, the crank pins, which are of steel, being 1 inch larger. The shaft is built up, the crank webs, shaft, and crank pins, being all separate pieces fitted and shrunk together hot. Built-up shafts are growing in popularity for large steamers. They were first used, we believe, by Mr. Wallace, of Liverpool, in the ships of the Allan line. The great advantage which they possess is that, should one give way, it can be readily and quickly replaced. To forge and finish such a crank shaft as that of the Orient would occupy at least three months, and the loss of the ship's time while lying idle waiting for the new shaft would represent a large sum of money.

When a built-up shaft gives way it is taken out, heated, and the cracked crank pin—let us suppose—is forced out by hydraulic pressure, and a new one put into its place. The entire operation from first to last would probably not occupy more than a fortnight. There are in the Orient four bearings for the three cranks, and these being kept in proper order, the strains on the shaft will be much simplified, and the chance of failure reduced. The maximum strain to which any crank pin will be exposed will amount to about 70 tons.

The screw shaft is 18¼ inches in diameter, and the screw is four-bladed, right-handed, 23 feet in diameter and 30 feet pitch. The blades are of steel, cast by Messrs. Vickers, of Sheffield, and the boss is of malleable, or, more strictly speaking, annealed cast iron. The blades are slightly bent backward to reduce vibration. The thrust bearing is not only secured to the ship, but is bolted to a long casting, one end of which abuts on and is bolted to the main engine frames, so that it is impossible for an undue strain to be thrown on the crank shaft by the shifting of the thrust bearing. The bearing stands some 4 feet high, and is accessible all round It is made with eight collars, and the block bearing surfaces are adjustable by brass nuts.

It would not be easy to find a better job than this thrust block, and we shall be much mistaken if it ever gives an hour's trouble while the ship is at sea The screw tunnel is about 5 feet high by 4 feet wide. All the couplings on the shaft are fitted with guards to prevent accidents to engineers when oiling the shaft bearings. Access to the tunnel can be obtained with the greatest ease, and in this respect the ship presents a marked contrast to many which we would name, in which the screw shaft has been made as difficult of access as possible.

There are two surface condensers, or rather the tubes are arranged in two lengths in the condenser, which runs the whole length of the engine on the starboard side. One end of it is shown in our engraving. The tubes in each set are 14 feet long, the total length of the condenser being thus considerably over 28 feet. The tubes are packed by being passed through holes in sheets of India rubber, which are kept up to the tube plate by the pressure of the air.

The condensing water is driven through the tubes by two of Gwynne's centrifugal pumps, either of which could do the work. The pumps stand on the starboard side of the engine room in the wing. The condenser has 10,924 square feet of cooling surface, or, as nearly as possible, two square feet per indicated horse power, an unusually small proportion. The gear for driving the air and bilge and feed pumps looks very light. It is by no means so heavy as the valve gear. As it has not to work circulating pumps, however, it will probably be found strong enough.

Should the engines ever break down it is possibly here that failure will take place. In the port wing of the engine room stands a double cylinder vertical engine about 10 horse power, which drives spur and worm gear for turning the main engines when in harbor.

Steam is supplied by four circular double-ended boilers, each 15 feet 6 inches in diameter and 17 feet 3 inches long. In each boiler are six furnaces, 4 feet in diameter. The grates are 6 feet long. The safety valves are loaded to 75 lb. on the square inch. There are two vertical superheaters, one to each funnel. The boilers are grouped in pairs, and are fired fore and aft from one double and two single stoke holes.

Coal-bucket railways are provided in each, and a regular tram road is laid down the center of the main bunker, which runs forward a distance of 120 feet in the ship. The bunkers hold 3,000 tons of coal, and the ship is expected to burn 2,500 to 2,800 tons on her voyage out to Australia, which will be made by long sea, the return trip being *via* the Suez Canal. Engines are provided for hoisting up ashes and various other purposes to the number of sixteen, including five very powerful steam winches.

The ship is steered by steam power from a wheel house forward on the hurricane deck. The wheel is not larger than that of a yacht, and a boy could maneuver the ship in a gale. The rudder is worked by one of Muir & Caldwell's steering engines, placed close to the rudder head. There are two large hand-steering wheels also provided, so that should any accident happen to the steering engine, manual power could be at once brought to bear.

While it is indisputable that the engines of the Orient are admirable specimens of workmanship, there are several features in their design which will hardly escape criticism. We have already explained that three-cylinder engines have the defect of taking up great length in a ship, and this defect has been exaggerated in the engines of the Orient by placing the cylinders comparatively far apart.

It may be argued that the position, number, and dimensions of the crank shaft bearings virtually determine the length of a marine engine, but this is only true under certain conditions. The engines of the Orient are prolonged by the position of the eccentrics on the crank shaft.

In the Creusot engines the eccentrics are carried on a counter shaft driven by gearing from the main shaft, an arrangement which is found in practice to work very well. It may be urged that in this way the valve chests cannot be got between the cylinders, but they are not between the cylinders in the Orient.

Another point worth notice is the use of piston valves. These are comparatively unknown at sea and are very sparingly employed on land. They are very liable to become leaky, and as they will have to run without examination for as much as six weeks at a time in an Australian steamer, it appears to us that some risk attends their use. Should they leak the loss of steam will be very considerable. The results obtained with them will be looked for with interest by engineers. If only a good piston valve can be got, its advantages over the ordinary slide would at once secure its extended adoption. Valves of the kind have been used in the Pacific boats for some time, and we have heard no complaints concerning them.

The great length of the condenser tubes, 14 feet, will hardly escape attention; from 6 feet to 8 feet is the normal length. It may be argued that by the time the condensing water has traversed 8 feet or 9 feet of tube it will have become so hot that the remaining 5 feet or 6 feet of tube will be useless; but this is not so. The efficiency of a tube of any length varying with the velocity imparted to the water flowing through it, the greater the speed the greater the length of tube which can be usefully employed. Messrs. J. Elder & Co. succeed at all events in obtaining a splendid vacuum in all their marine engines.

We have now given, as far as lies in our power, a description of the Orient and her engines, but we feel that we have done them but scant justice. A great ship is an overwhelming subject to descant upon, and, after all has been said that it is possible to say within a reasonable space, much more remains left unsaid. The Orient will probably not long be left alone.

The development of our trade with Australia will grow apace in the hands of such men as those who compose the Orient Steam Navigation Company. Such ships as that concerning which we have endeavored to impart to our readers an adequate conception are the glory of Great Britain. In no other country are vessels of the kind built. It is more than doubtful if France possesses in any private shipyard the skill and resources necessary for the successful accomplishment of the task.

In shipbuilding and marine engineering the United States at present holds a most subordinate place. The carrying trade of the whole world is practically in English hands, and in them it is likely to remain for a long while to come. Year after year shipowners and shipbuilders and marine engineers venture on higher and higher flights, and it is not easy to see where the end will be. As it is, we possess fleets of passenger steamers which no other country can parallel. We imagine that a limit has been reached, and just when men have arrived at this conclusion such a vessel as the Orient takes up her berth in a London dock, and practically brings Australia nearer to us than America was to the men of the last generation.

The Orient promises to be a fast and very comfortable ship. She made the run round from the Clyde to the Thames, off Margate, in 49 hours 55 minutes, or at the average rate of 14·9 knots per hour. In the Channel a speed of 16·7 knots was maintained for two hours. It must not be forgotten that the weather was very boisterous, and that the stokers were of indifferent quality. Although an Atlantic sea and a heavy gale were caught off the Tuskar Rock, the motion of the ship was extremely slight. Those who go to sea in her may, we think, rest assured that they will be carried speedily, safely, and with a maximum of comfort to their destination. We may add that on the run the engines worked very coolly, and gave no trouble.

All the arrangements were made by Mr. A. D. Bryce, who ably fills the post of superintendent for Messrs. J. Elder & Co. Mr James Dick, superintending engineer for the owners, took charge of the engine room when the ship was handed over to her proprietors. We are indebted to the courtesy of Messrs. Anderson, Anderson & Co., Captain Andrew, captain superintendent of the company, and Mr. Dick, for facilities afforded us in preparing the information we have placed before our readers.—*The Engineer.*

THE THEORY OF THE COMPOUND ENGINE.

"A STUDENT'S" letter justifies us in publishing an explanation of part of the theory of the compound engine in the simplest form. We have reason to know that our correspondent does not stand alone, and that many men who have long passed the student period of their lives but dimly understand the principles of operation of the compound engine; while others who have to do with such engines every day, and all day long, know really nothing about the matter, save that "the steam is used twice over, first in one cylinder and then in another." Those who have received an adequate mathematical training can easily be made to comprehend mathematical truths, even when these truths refer to branches of science with which they have had little or no previous acquaintance.

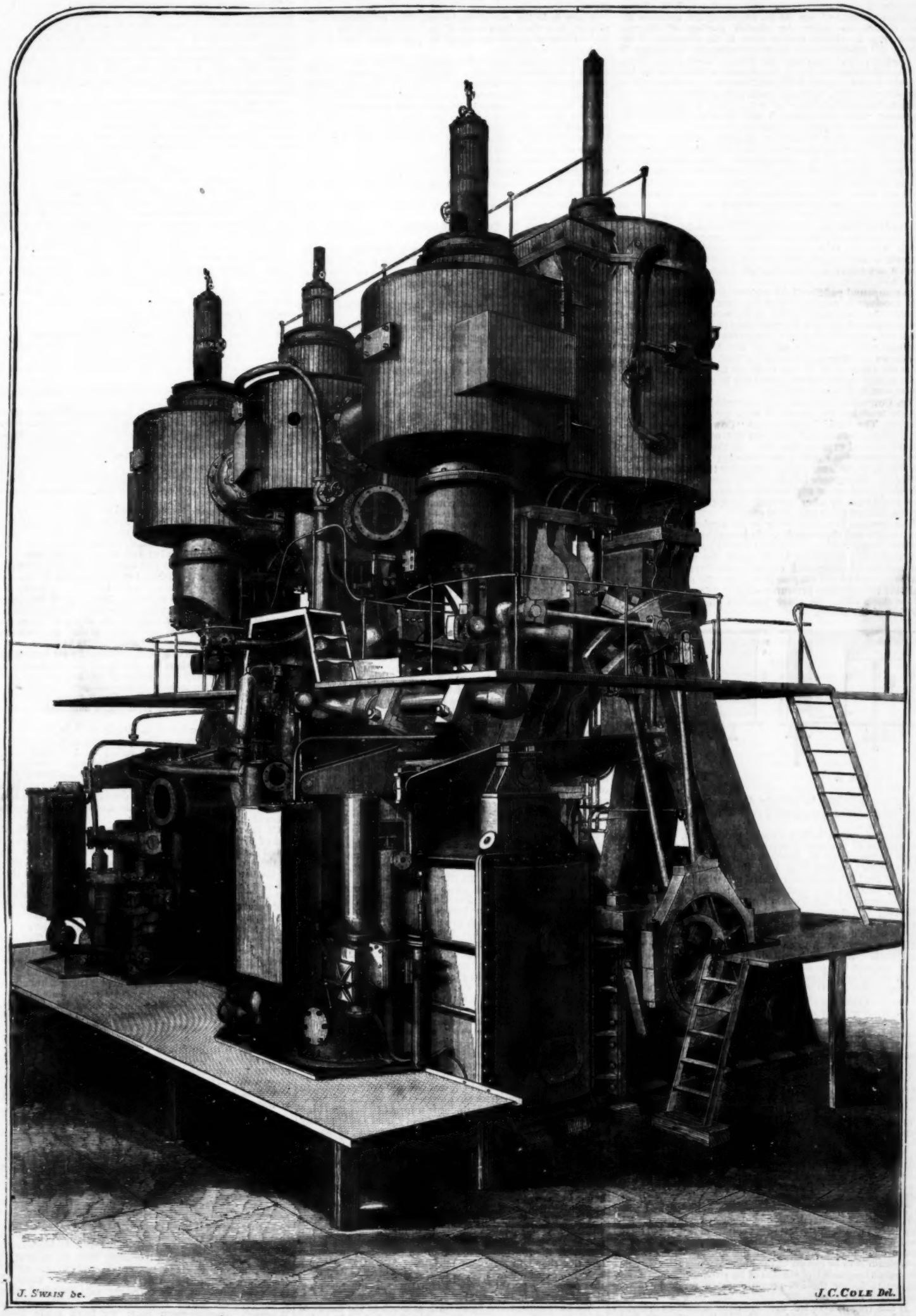
But it is far otherwise with men whose training has been imperfect, either from accident or distaste for apparently dry reading. It so happens that no book exists in which the theory of the compound engine, or indeed of any engine, is stated in language which may be readily understood by any one who knows no more of mathematics than is represented by arithmetic; and a search for an explanation of the principles involved in the action of heat engines of any or all kinds usually results in disappointment, the would-be learner rising from the perusal of chapters on "expansion curves," "adiabatic lines," "thermal equivalents," and such like without any clear idea of what the author whose pages he has consulted means; or more than the most vague notion of how his statements and propositions are to be employed in practice.

Thus it happens that when called upon, it may be, to design a compound engine, the luckless seeker after knowledge finds himself completely at fault. The best he can do is to fall back on the practice of others, and to become a slavish copyist. It now and then happens that otherwise skillful engineers have to design engines of a type to which they are totally unaccustomed. They fly to books of reference for aid, and they are immediately lost in a wilderness of knowledge, because they know not in what direction to seek for precisely what they require. It is quite possible to make enough of the theory of the compound engine so far clear to non-mathematical readers that they may be able to calculate the dimensions of such an engine for any given power, and may be able to say why the dimensions they adopt for their cylinders are the best possible. But, on the other hand, they must be prepared to take certain statements as being true without proof, for the simple reason that none but those who have received some mathematical training could understand the proofs which they wish to see.

As this article is intended for those who have much to learn concerning the compound engine, it can be read with little benefit by those who have nothing to learn. It is strictly elementary, and those who feel disposed to be critical will do well to bear the fact in mind.

The compound engine is one in which the steam, having first acted on one piston, is, instead of being discharged into the air or a condenser, then permitted to act on another piston. In practice it is usual to make the cylinder which first receives steam from the boiler smaller than the second cylinder, but this is not absolutely necessary. It is done in practice to equalize the strains on the machinery; for let it be supposed that we have two cylinders, A and B, both of the same size, and that steam of 60 lb. pressure is permitted to act first on the piston in A, and after expansion on the piston in B. As a consequence of this expansion the steam acts on B with a pressure of, say, 15 lb. on the square inch. Then the second piston rod would be submitted to a less strain than that thrown on the first piston rod. As, however, the space between the two pistons is occupied by steam having a pressure of 15 lb. on the square inch, which pressure is driving B and resisting the motion of A, then the net strain on A is 60 lb. — 15 lb. = 45 lb., while the net strain, neglecting back pressure, on B is but 15 lb., or one third as much. In order to get rid of this disparity, the first or high-pressure cylinder is almost invariably made smaller than the second or low-pressure cylinder, in such a ratio that the strains on both piston rods shall be as nearly as possible the same. For example, let us suppose that the pistons A and B had each 1,000 square inches of area, corresponding to a diameter of a little less than three feet. Then the strain on A would be $(60 - 15) \times 1{,}000 = 45{,}000$ lb., and the strain on B would be $15 \times 1{,}000 = 15{,}000$ lb. If, now, A was made, say, 21 in. diameter, then the strain on it would be $(60 - 15) \times 350 = 15{,}750$ lb.; in this way the strains would, it will be seen, be very nearly equalized.

Another reason for making one cylinder smaller than the other is to reduce the total strain on the machinery which would otherwise be caused by admitting steam of a very high pressure to act on a large piston. The small cylinder is in other words adopted, not only to equalize strains and make the crank shaft revolve at a nearly uniform speed, but



COMPOUND THREE CYLINDER ENGINES OF STEAMSHIP ORIENT. [See page 3239.]

as a measure of precaution to prevent the breaking down of the machinery.

When men who are unaccustomed to deal with compound engines are called upon to design them they find themselves met at the outset by a difficulty which may be thus explained: A is at the beginning of its stroke, so is B. Steam having a pressure of say 30 lb. fills the space between the two pistons, as shown by shaded portion of diagram below, Fig. 1. As the pistons move in the direction of the arrows the space between them is continually increasing in dimensions, and by the time the pistons have assumed the position illustrated in Fig. 2, the pressure as shown by the less densely shaded portion will have fallen to say 10 lb. It is obvious, therefore, that the small piston will have a continually diminishing force of retardation acting to oppose its ascent, while the piston B will have a continually diminishing force tending to cause its descent.

To calculate what the average pressure between the two pistons will be is *apparently* necessary in order to determine the power given out in each cylinder. This calculation is easily enough made when engines work with cranks opposite each other. In practice, however, such engines are seldom met with. The cranks are always placed at some angle to each other, varying between 90° and 120°; the former is the rule. This being the case, it will be seen that B is beginning its stroke just at the moment when A has made one-half its stroke, and *vice versa*. Thus it happens that B may not be ready to take the steam discharged from A at the moment when it reaches the end of its cylinder, and what is known as a reservoir or intermediate receiver is provided to hold it.

In compound paddle-wheel engines of the oscillating type this receiver is usually placed between the cylinders and beneath the floor plates of the engine room. In the case of screw engines it either takes the shape of a jacket round the small cylinder, bringing up its apparent diameter to that of the large cylinder, and so making the design symmetrical, or else a very large pipe is used to lead the exhaust steam from the valve chest of one cylinder to that of its fellow. As it is evident that steam should not be allowed to cool in the reservoir, it is well clothed.

Mr. Cowper several years ago patented a system of artificially warming the reservoir with fresh steam from the boilers. The device was known as "Cowper's hot pot," but experiments showed that the gain did not compensate for the trouble and expense incurred. In the early days of the compound marine engine it was believed that the reservoir must be large, at least equal in capacity to the low-pressure cylinder. Experience has, however, proved this idea to be fallacious, and screw engines with right angled cranks are now made with no other reservoir space than that supplied by the exhaust ports and valve chests.

The pressure in the reservoir or its equivalent fluctuates continually and rhythmically. It is possible to calculate its amount, but not easy, and it need hardly be said that such a calculation is a stumbling block which the non-mathematical designer of compound engines falls over at once. It forms no part of our purpose to explain the method of calculating intermediate pressures—that is to say, the pressure of the steam filling the space between the pistons at any portion of the stroke.

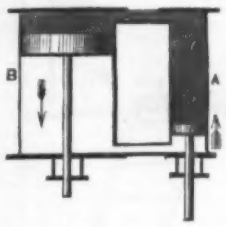


FIG. 1.

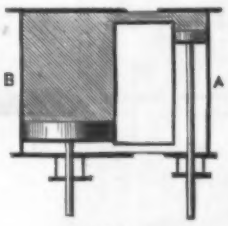


FIG. 2.

This pressure may be entirely disregarded in calculating the dimensions of a compound engine to work up to any given power.

This may appear to be a strange proposition, seeing that the amount of pressure between the pistons determines how much power shall be developed in each cylinder. It is nevertheless true that it is with the pressure in the valve chest of the high-pressure cylinder, and with that in the condenser, that for practical purposes we have alone to do. This statement is a deduction from the proposition that the efficiency of a steam or other heat engine is entirely independent of the number of cylinders through which the fluid passes while doing work; that is to say, one pound of steam will do as much work in expanding through a given range in a single cylinder as it will do if expanded through the same range in two or any greater number of cylinders. The proof of this truth is easily given.

Many years ago Carnot, an eminent mathematician, demonstrated that the efficiency—that is to say, the power of doing work—of any hot air, steam, or gas engine, depended solely on the difference between the temperature, T, at which it received the fluid, and the temperature, *t*, at which it rejected it. Now it is evident that the number of cylinders used will not affect the temperature at which steam enters the first cylinder, because that temperature is fixed by the pressure in the cylinder at the moment the piston begins to make its stroke. Nor can it affect the temperature at which the steam is discharged, because that also is fixed by the pressure chosen for the moment the exhaust port opens. But the initial and terminal pressures may be entirely independent of the number of cylinders; because, for example, steam may be expanded ten times just as well in one cylinder as in two or more. From all which it follows that in calculating the proportions to be given to the cylinders of a compound engine, we may disregard the pressure between the two pistons, and proceed as if all the power were to be developed in one cylinder only.

This cylinder will be the low-pressure cylinder, and when its dimensions are fixed, those of the other cylinder may be deducted from it by the following empirical rule based on the best modern practice: The high-pressure cylinder is to be made one-half the diameter of the low-pressure cylinder, and steam is to be cut off in the high-pressure cylinder when the piston has made five-eighths of its stroke, and is to be permitted to follow the low-pressure piston for about seven-eighths of its stroke.

If this rule be adopted, the work done in the two cylinders will be very equally divided. Should it be thought desirable to expand the steam a little more, and cut off, say, at half stroke in the small cylinder, then this last may be made a little more than half the diameter of the low-pressure cylinder. Should it be thought better to expand a little less, then the high-pressure cylinder may be made a little smaller than half the diameter of its fellow. The rules here laid down are very seldom indeed departed from in practice, and the results obtained by observing these rules are uniformly so satisfactory that no reason exists for using any other.

When, as in the case of the Orient, three cylinders are employed, then the united areas of the pistons of the low-pressure cylinders should be equal to four times that of the high-pressure cylinder.

To find the total range of expansion, divide the capacity of the low-pressure cylinder, plus ports and passages which are emptied into the condenser, by that of the space swept through by the high-pressure piston while taking steam from the boiler, plus the capacity of ports and passages emptied into the large cylinder. When two low-pressure cylinders are used, as in the Orient, the rule is just the same, bearing in mind that each large cylinder is virtually filled twice by one small cylinder full of steam.

In order to make what we have said quite clear, we shall now give the calculations required to determine the capacity of the cylinders of a compound engine intended to indicate 500 horse power.

One horse power is equivalent to 33,000 lb. raised a foot high in a minute.

Then, $33{,}000 \times 500 = 16{,}500{,}000$ foot-pounds per minute.

Screw engines of 500 horse power make from 60 to 70 revolutions per minute, corresponding with a 3 ft. stroke to 360 ft. to 420 ft. of piston per minute. We may take the latter velocity as consistent with good modern practice.

Then, we have $\frac{16{,}500{,}000}{420} = 39{,}286$ lb. in round numbers as the gross pressure which must act on a piston moving at 420 ft. per minute in order that 500 indicated horse power may be developed. It is evident that this number, divided by the average pressure per square inch, will give as a quotient the number of square inches of area which the piston must have.

It will be seen that in all these calculations we proceed as though the engine was to have but one cylinder. We have now to find the average pressure in the cylinder throughout the stroke. This is an exceedingly simple matter, albeit it now and then sorely distresses students. We must first find how many times the steam is to be expanded and its pressure when it first enters the cylinder. It may be assumed that a modern compound screw engine will work with a boiler pressure of 70 lb. safety valve load. In all that follows, however, the safety valve load is to be entirely disregarded, and nothing must be dealt with but the absolute pressure of the steam—that is to say, the boiler pressure, plus 15 lb. for the air pressure; the gross boiler pressure then we suppose to be 70 + 15 = 85 lb. It will be safest to assume that 5 lb. of this pressure will be lost between the boiler and the cylinder. The initial cylinder pressure will be 80 lb.

To find the ratio of expansion, let us assume that we shall use two cylinders, one having one-fourth the capacity of the other, and that in the first steam shall be cut off at each stroke. Then it is clear that the ratio of expansion will be eight to one—neglecting clearance, etc., for the moment—which is quite as much as is consistent with economical working.

In "Molesworth's Pocket-book" will be found a table of hyperbolic logarithms. Every engineering student is supposed to have a "Molesworth," so we name it, although tables of hyperbolic logarithms will be found in many other works. The student who knows nothing of logarithms need not be frightened; they will give him no trouble in this case. Opposite 8 he will find 2·079; add 1 to this and we have 3·079; multiply this by the initial pressure of the steam, or 80 lb., and we have 246·320. This is to be divided by the exponent of the ratio of expansion—that is, by 8—and the quotient, 30·79, will be the average pressure in pounds of 80 lb. steam expanded eight times. For any other ratio of expansion we proceed in the same way, using the hyp. log. of the ratio.

The movement of the low-pressure piston of a compound engine is resisted by the pressure of the uncondensed steam, a perfect vacuum never existing in a condenser. The back-pressure in different engines varies. It may be taken to be about 3 lb. But to be on the safe side we assume it to be 3·79 lb. Deducting this from the average pressure, 30·79 lb., we have left 27 lb. as the net effective pressure.

We have seen that the gross effective pressure on our piston must be 39,286 lb. Dividing this by 27 we have 1,455 as the number of square inches of area which the piston must possess, that is to say, the piston must be a little more than 43 in. in diameter; the small cylinder is to be one-half this. So our compound engine, to indicate 500 horse power, will have two cylinders, one 43 in. and the other 21·5 in. in diameter, with a stroke of 3 ft.

We have now to consider another factor in our calculations, which is, that in all compound engines a loss of pressure occurs between the low-pressure and the high-pressure cylinder, due in part to the reservoir space between them, and in part to condensation caused by cooling. The result is what is known as "the gap" met with in the diagrams taken from all compound engines; that is to say, when the diagrams from the high and low pressure cylinders are put together a gap or interval of greater or less dimensions always exists between them. With the effect of the gap on the economy of compound engines we need not now concern ourselves. It is enough for our purpose to know that the pressure in the low-pressure cylinder is in practice never so high as it ought to be according to theory, and consequently some addition is always made to the dimensions of an engine to allow for this. The allowance varies. Ten per cent. will not be too much, and in order that we may be certain that our compound engine will really indicate 500 horse power with 80 lb. steam expanded eightfold, and with 420 ft. of piston speed per minute, the cylinders, instead of being 43 in. and 21·5 in. in diameter, ought to be 45 in and 22·5 in. in diameter.

Those who master what we have endeavored to explain will see that to calculate the principal dimensions of a compound engine of a given power is by no means difficult. By following the rules we have laid down they may rest content that they will make no mistakes. We have not professed to explain how a compound engine is to be designed; that cannot be taught by books or papers. It must be practically learned in the drawing office and the works.

We have endeavored to set forth as much of the theory of the compound engine as will enable the student to understand the broad principles of its action, and the basis on which rules for proportioning its dimensions rest; and we trust that in doing this we have satisfied the wishes of a "Student" and his fellows.—*Engineer*.

[Continued from SUPPLEMENT, No. 203.]

AMERICAN ENGINEERING.—VIII.*

GAS ENGINEERING.

To represent gas engineering, the society was able to exhibit drawings and photographs of works and apparatus as employed in this country, which in some respects are novelties. The progress made in this branch of engineering is perhaps more marked than that of any other department. In fact, the beginning of the century knew no such business; fifty years ago New York city had no gas, and forty years since, all the gas supplied to the people of Boston was made in one iron retort.

The amount of capital now invested in this business in New York city and Brooklyn is represented by about thirty millions of dollars, and the number of works, great and small, throughout the country is about one thousand. The principal progress that has been made since the earlier days of gas lighting consists in the various scientific and mechanical means introduced for the proper treatment of the products derived from the destructive distillation of coal, so that while those portions that constitute the light-giving power of the gases evolved are carefully separated in a state of "purity" or freedom from the more deleterious elements, the other portions are still preserved, and handled in such a way as to be no longer "waste products," but sources of revenue in the production of articles of great value and usefulness in the arts. And while this country cannot claim so great a degree of perfection in this latter respect, viz., in the handling of residual products, as has been attained abroad, the reason for this is to be found in the fact that the newness and fertility of our country does not afford the same market demand for these products.

The exhibits under this head consist of—

A detailed drawing of a multitubular condenser.

Photographs of a modification of the Livesey scrubber, with an automatic water distributing apparatus.

A complete drawing of the works of the New York Gas Light Company.

Photographs of the Nassau Works of Brooklyn, etc.,etc., etc.

The multitubular condenser is an apparatus for condensing the tar from the gas. It consists of a cast iron box, or series of boxes with two horizontal diaphragms or partitions—one near the top, the other near the bottom; the upper and lower spaces thus formed are connected by cast iron pipes, usually about four inches in diameter, placed as closely together as possible. The middle space of the box is filled with water, which consequently surrounds the pipes above mentioned.

A series of boxes thus arranged are placed side by side, the gas is admitted into the lower space and passes up through the pipes to the upper space, from there it goes to the top space of the next box, down the pipes to the bottom space, thence into the next box, up the pipes, and so on, thus traveling up one set and down the other until the temperature of the gas is reduced sufficiently low by the water surrounding the pipes to cause the tar, etc., to be deposited in the lower space, from which the tar is run off into cisterns constructed for the purpose. The water surrounding the pipes is admitted from the end of the series of boxes opposite to that at which the gas enters, so that the water surrounding the pipes through which the gas first passes is the warmest (the heat having been acquired by the flow of gas), and that at the end where the gas leaves the condenser is the coolest. In this way the cooling of the gas goes on gradually, and is not too sudden in its change of temperature at any point, and the rapidity of cooling is easily controlled by regulating the amount of fresh water admitted to the condenser.

This form of condenser is largely used in this country, but is almost unknown in Europe, where, as a general thing, the temperature of the air is relied upon to cool the gas, which is passed through pipes out of doors for the purpose. The great advantage of the multitubular method is the almost perfect control that it gives the manager over the rate of cooling. In submitting the drawings of this apparatus, the society was enabled to present a novelty to the gas engineers of Europe.

Of the scrubbers, of which photographs were submitted, and of which a drawing is shown, the principal novelty consisted in the method of distributing the water. The object of the scrubber being to remove the ammonia from the gas by the use of water, by means of the distributer on the top the same water that is used to wash the gas is made to distribute itself by passing from a tank overhead, to which it had been previously pumped, over an overshot water wheel, which, by suitable gearing, turns two arms within the top of the scrubber, into which the water is conducted by a pipe leading from a trough under the water wheel. These arms are in the form of troughs, with notches cut in the edges, so that as the arms revolve horizontally the water drops on to the wooden slats with which the scrubber is filled. These slats being put in edgewise, and kept a small distance apart, a very large area of wetted surface is presented to the gas as it passes through. The ammonia is taken up by the water, which passes off from the bottom as "ammoniacal liquor," and is collected in cisterns built for the purpose. The gas enters the scrubber at the bottom, and passing up to the top, is taken out by a central outlet pipe, which extends to the top. The gas on entering comes first in contact with the strongest liquor, and leaves through a spray of clean water. The strength of the liquor obtained from these scrubbers is from 16 to 20 ounces Twaddle. The quantity of water used is about one gallon to 1,000 feet of gas.

THE COSTS OF RAILWAY CARS.

MR. URI GILBERT, President of the Gilbert and Bush Car Co., of Troy, N. Y., testified before the Railroad Investigating Committee, as follows, in reference to the cost prices of cars:

"I am not familiar with the prices of other car companies; the average price of box freight cars is $400 to $450; those that we made three years ago cost $550; the highest price that I know to have been paid was $1,200; their reduction was made since 1872; that price prevailed during war times; a milk car costs about $100 more than an ordinary box freight car; a baggage car truck and a passenger car truck are about the same; a baggage car costs about twice as much as a box freight car; the usual price of a baggage car varies from $2,000 to $2,200. We make Wagner's drawing-room cars; we have made them as

* American Engineering as illustrated by the American Society of Civil Engineers at the Paris Exhibition of 1878. Compiled by George S. Morrison, Edward P. North, and John Bogart, Committee, Transactions of the Amer. Soc. of Civil Engineering.

cheap as $8,000; that was a cheap car. Our usual price is $12,000; it includes the chairs, carpets, mirrors, etc.; we manufacture sleeping cars; I find that we have made drawing-room cars for the Delaware and Hudson Canal Company in 1870 for $11,600; we get now $13,600 for a sleeping car; we haven't made Mr. Wagner any since 1874; that price did not include sheets, pillows, and blankets; he has paid us more than that for cars; he has paid us $14,000 for many cars; our cheaper drawing-room cars, four wheels, we make for $10,000; we make cattle cars; we have sent a great many of these cars to South America; the ordinary mail cars cost from $20,000 to $30,000; the distributing mail cars cost more. The reason we can't compete with Western manufacturers is that they are in the lumber districts and they use poorer iron, and they don't season their materials; the prices named are net; we have not built any cars for trust companies; we have built two hundred and fifty cars for the New York Elevated road; the net price was from $2,500 to $3,000; they furnished wheels on axles; that price covers everything; I don't know anything about the price of tank cars; as to the ordinary passenger cars, the last that we built cost $4,200; the last that we built for the Hudson River road cost $5,400; that included a heater and some other extra fixtures; I have never made any large coal cars; the price of the small car for carrying coal was $200, but that is no criterion to go by for the coal trade."

MACHINERY FROM AN INSURANCE POINT OF VIEW.

By A. J. WATERS.

THERE is much in a machine shop which is both instructive and interesting—instructive as showing the fertile energy of the inventive mind—interesting in illustrating the various mechanical devices used as the conservators and distributers of forces. The proper use of these latent and active forces; their relation to mechanical effects; their connection as elements of motion, and their agency in producing combustion, interest alike the mechanic and the underwriter. While the former would view them as the employment of principles susceptible of improvement, or as mere demonstrators of mechanical theories—the latter looks upon them as factors in a problem embracing the law of values and their probable relation to the fire account. The swift revolving pulley, the whirling of the belts and movement of the machine present to the mind of the artisan the one thought of utilized forces and manufactured results. The underwriter accepts them as so many elements of wasting material, decrease in values, and possible aids in producing ignition.

The friction of a belt or wheel to one is simply an abuse of mechanical power, the remedy of which is desirable only so far as it results in the economy of force and an increased factor in production. To the other the mechanical effects of friction are at once viewed in the light of a possible fire hazard, and an increased diminution in value of the machine.

Even the dust and dirt of the shop presents to the two minds a totally diverse practical view.

While the one is contemplating its presence as an indicator of a lack of care and cleanliness, and an added useless force to be overcome, the other plainly sees an increase of hazard and an additional factor of depreciation.

Each forms his conclusions from his individual manner of thought, and the vantage of self-interest. The premises assumed are alike—the conclusions diverse.

It is only by a careful study of these diverse conclusions that we are aided in compassing the entire field of inquiry, and deducing results alike beneficial to the artisan and the insurer.

Everything in the world of nature has its growth and decay. The cessation of the former is but the beginning of the latter. So it is with all the ingenious works of man, with this difference—nature being perfect makes no mistakes—while the grandest results of man often owe their very origin and trace their beginning from the obscurity of oft-repeated blunders. The one is the production of an infant mind, the other that of an intellect whose every movement shows the finite. With one, the elements of natural decay, making new combinations, are the only changes. With the other, the same forces act with equal celerity, and also bear in addition the waste arising from forces purely mechanical in their operations.

FRICTION.

From the time the band first tightens on the pulley, or the cog in the wheel commences its revolutions, the wear caused by friction at once begins and a gradual depreciation ensues. The depreciation by *wear* largely depends upon the rate of motion, the force to be overcome, and the nature of the material used. Again, the rate of motion as a power in accelerating depreciation depends largely upon the size and weight of the shaft and pulleys. A small wheel might be made to revolve 8,000 revolutions a minute and cause but little wear either in shaft or boxes, while another four times its size, running at the same rate of speed, might in a very short space of time wear itself entirely out. The force to be overcome is also susceptible of many modifications. An engine made to perform an eight-horse power would run for years without any material decrease in value; but increase the resistance to be overcome from eight to ten horse power, and load the engine with this additional work, and the depreciation is at once nearly doubled. All these elements need consideration if a correct depreciation arising from use be desired. Again, the depreciation of a piece of machinery, so far as regards a diminution of its selling qualities, depends somewhat upon the standard assumed. If we assume as a standard the depreciation which affects alone the running character of the machine, as seen in the results of its working, the actual lessening of its value might be comparatively insignificant; but when we add to this the market standard and estimate its value from its probable *salable* qualities, the solution of the problem brings far different results. A second-hand machine, even though perfect in all its parts, depends for its value upon various conditions, any one of which might indirectly advance or decrease its selling qualities. And yet in fixing absolute values it would be hardly equitable to the owner to take the machine from its connection and estimate its actual worth by what it would bring as a separate machine; or even taken in connection with others, fix its value at what it would sell for in the market.

The depreciation implied in this paper is an actual and real diminution of value arising from age, use, and disuse. The first is an element of depreciation in a general sense, *only* so far as regards the period of time the machine has been used. And here again we have an extremely valuable standard from which to draw conclusions, the results of which largely depend upon the skill of the operator using the machine. As an illustration, we take a single spindle machine, reversible shaper—a machine in daily use in furniture manufactories. This will cost new $125, and a full set of moulding cutters, say $200.

The average speed of the spindle is about 6,000 revolutions per minute. Recently I examined a machine of this class which had been in constant operation during working hours for eight years, without even having the boxes rebabbitted.

The wear on the journals was scarcely perceptible; the cutters were all sharp and true, and the actual decrease in value for the eight years would hardly exceed ten per cent. of the first cost.

COMPETENT AND INCOMPETENT WORKMEN.

A few days after I was in another factory and saw the same kind of a machine, identical in size and pattern, and doing the same class of work, which had been running but five years, and the owner's admitted depreciation of value was fifty per cent. One had been run by a practical mechanic, able to detect and remedy the least inaccuracy in running; the other was worked by a cheap grade of labor, whose value depended solely upon his work passing muster, utterly regardless of the undue labor put upon the machine to accomplish the result. Running the machine the same length of time as the first mentioned, and its cash value would be but $65, while the former would be worth $192.50. These may be extreme cases, and yet they are selected from everyday observation, and fully illustrate the fact that the depreciation by use largely depends upon the amount of brains the operator puts into his work. It is possible for a good mechanic to run some of the rapid moving wood-working machinery for ten years and not cause a depreciation to exceed ten per cent., while a careless, incompetent hand might in one year, by improper gearing, tension of the belts, neglect in cleaning and oiling and other causes, decrease their work-producing qualities fully fifty per cent., and perhaps render the machine entirely valueless. The large demand for cheap goods, or good goods at low prices, has resulted in the employment of large numbers of cheap hands. The least expensive hand that can run the machine and get out the work too often supplies the place of the experienced mechanic, and as a result the percentage of depreciation is largely on the increase. As a general rule, it is safe to say that during the past four years the actual depreciation from this cause alone has been greater than for the preceding eight years.

THE TENSION OF BELTING.

There are minor causes, simple in themselves, but which combined form very strong elements of depreciation. We refer to one which is often entirely disregarded, and that is the tension of the belting. By having a belt sufficiently tight to convey the power and not slip on the pulleys, or so actually arranged as to just do the work easily, the depreciation on the machine may be decreased two per cent. a year, and on the belting over twenty per cent. This is further seen when we consider that a 3-16 inch leather belt, three inches wide, has a breaking tension of 2,400 pounds, and any ordinary machine run with this size belting can be successfully worked with permanent tension of 180 pounds. Doubling the tension, while it would not break the belt, yet the additional force constantly employed—being an increase of about 1-13 of its breaking tension—is so much useless friction to be overcome on the pulleys, and an additional strain on the entire machine expended to resist the force, and a consequent added element of actual wear. In machinery driven by gearing, a small variation in the level of the counter shaft which carries the wheel working in to the cogs of another will sometimes double the per cent. of actual wear and treble the friction. Cog wheels *must* work into each other accurately and truly, as a slight variation will cause them to wear unequally, eventually give unsteady motion to the balance of the machine, and soon materially lessen its usefulness.

Again, the solidity with which a machine stands upon the floor is an important element of wear. If a constant unequal jarring is perceptible in the running of the machine, the resistance of this outside force has a tendency to spring the lighter parts of the machine, cause an uneven running of the journals, wear out the boxes, and materially hasten its dissolution. When this exists to any considerable extent it will cause an increase in the wear of the machine of at least three per cent. a year, and in some cases even more. Then, there are overworked machines—that is, machines capable of doing a given amount of work without unnecessary friction and wear; but such, by high gearing, causing an added speed and faster feeding, puts upon the machine an increase of labor beyond what it is intended it should do, and the result is rapid depreciation and an early breaking down of the machine.

DUST AND DIRT.

Dust and dirt accumulating on and in the boxes and journals is another important factor in estimating depreciation. Nearly all dust contains, to some extent, gritty particles; these work into the oil and grease around the journals, and materially aid in cutting away both journals and boxes. As a general rule, several of the items mentioned are not only productive of decrease of value, but are frequently the cause of disastrous conflagrations. An excess of friction even between two pieces of clean iron will cause fire, and when to this is added the elements of grease and dirt the danger is doubly imminent.

It is well in estimating values before a fire for the supervising agent to bear these facts in mind, as they are not only important in reckoning actual values, but often prove lurking incendiarism. Calling the attention of the owner of the property to these little omissions, and having them corrected, may often save the company a possible loss.

Although this may seem somewhat of a digression, yet allow me to suggest that a more intelligent inspection of our special hazards in regard to the points herein enumerated, and others which will suggest themselves, would not only be a mutual aid to the special agent in acquiring valuable information, but a decided saving to his company in its loss account. Intelligent criticism rarely gives offense, and the owners of machinery are scarce, indeed, who would not welcome practical suggestions tending to increase the efficiency of new machines, lessen the cost of running them, or decrease their fire hazard. Machinists, the reading of standard works, keeping your eyes and ears open, and remembering what is learned, will soon give any one a fund of information alike valuable to the supervisor or the adjuster. It is not enough to know that the outside exposures are all right, and that the moral hazard is unexceptionable; but in addition to this, the supervising agent should critically examine all the points of depreciation, as the element of wear and decay are often intimately connected with the elements of combustion. What will cause the one will often produce the other.

Occasionally there are supervisors who seem to look at every risk as if they expected it would burn. This is one of the very best standards from which to correctly value a hazard, as following up this expectation often brings to view many a lurking cause simply dormant, only awaiting favorable conditions to develop into a possible combustion. 'Tis said that to see is to believe, but in all such cases seeing should be at once followed by a prompt remedy, or failing in this, an equally prompt cancellation. The propriety of having memoranda of items of hazard in all classes of special hazards is one we cannot too highly commend, as it is not only a valuable aid in making an intelligent survey, but the only scientific basis on which to form a rate commensurate with the physical hazard. Before deciding upon the value of machinery as a part of policy *before*, or its value *at* the time of a fire, all these points need careful consideration, and especially the kind of work the machine has done and the skill of the operator using it.

Having hastily glanced at some of the causes of depreciation by use, we take up another element of decrease in values, an element far more detrimental to intrinsic worth than any or even all the causes yet enumerated, and one which, if prevailing to any considerable extent in a factory, is very apt, in connection with an increase of moral hazard, to prove the probable cause of a visit of the company's adjuster

We refer to depreciation by *disuse*.

The disuse of a machine as an element of depreciation is something which should receive careful attention. We mean machinery which has been superseded by more labor-saving and improved patterns. There are but a few factories but possess more or less of these discarded machines. They are neither worn out nor badly depreciated from actual use, but simply set aside to make room for others which will move and work better for the same expenditure. Ordinarily these machines are extremely unsalable, are worth on an average 25 per cent. of their cost, after a full allowance for wear and tear, and yet how often these very machines, which perchance for months have stood aside covered with dust, dirt, and *débris*, in the event of a fire, turn up in the schedule of the machinery destroyed in all their pristine splendor, and their faults and shortcomings forgotten, and only remembered as valuable machinery tenderly reserved for special services.

The invoice carries their value forward every year as an available asset of the concern—an asset which no mechanic would care to transfer to his shop for twenty-five cents on the dollar, but which appear on the insurance schedule, backed by the invoice and supported by the catalogue price as a valuable item, for which the insurance company is politely asked to donate to the extent of one hundred cents on the dollar of its original cost, less a very small depreciation for actual use.

Rapidity of production, with equal or better grade of work, is the necessity of the day, and the inventive genius of the world is hard at work originating and completing these improvements. So long as this restless, never-satisfied spirit is at work, so long will the old give place to the new, and the vital element of depreciation enter into the computation of values on all classes of machinery. At the present prices of manufactured goods producers cannot afford to work slow and defective machines when better ones can be had.

A case in point occurred under the writer's observation but a few weeks since. One of the largest furniture establishments in Cincinnati had been for some time experimenting on a new sand-papering machine, and after expending nearly a thousand dollars, succeeded in building a couple of them which did very fair work. Near by is another large establishment which has set up a new machine for the same purpose, and which did far better and faster work than the one referred to. This fact coming to the knowledge of the first mentioned firm, actual work proving its merits, they at once ordered a couple of the new machines, and the ones upon which they had expended nearly a thousand dollars were set aside as useless and superseded machinery.

This process is continually going on in regard to nearly every variety of machine, and is one of the most active elements entering into the complication of depreciation. It is, moreover, an element which is often lost sight of, not only with agents in placing insurance, but with appraisers in estimating the loss after a fire. It might not be inopportune to remark that the adjuster can here find an opportunity to enact the role of a discoverer, as too often these little peculiarities are not thought of sufficient moment for the claimant to call to the attention of the appraisers.

Frequently these discarded machines are sold to the country manufacturer at a mere nominal sum, and then the disagreeable duty devolves upon the local agent, and oftentimes the adjuster, to bring the prices within the range of a reasonable probability.

Depreciation by disuse is sometimes met in instances where the cost of the raw material, owing to scarcity, will not warrant the production of the manufactured article. As saw mills with no logs to saw; wood workers where the timber is all gone, and small woolen mills with the fleeces of the shearer in close proximity to a better market; stowing mills on dry creeks, and elevators away from the railroad; tanneries with no hides to cure, and cheesefactories with no patrons. It is useless to attempt any per cent. of depreciation on the above hazards. As well might we attempt to measure the decrease in values of the local roads, or estimate mathematically the actual depreciation of the machinery of the national board. It takes one away from the domain of mathematical possibilities, and presents a moral depreciation incomputable by arithmetical science.

Errors in construction-account of machinery is an item from which large savings can sometimes be had. An insurance company is not paid for making good the mistakes of a machinist. The construction-accounts are rare in which cannot be found double work on shafting and pulleys, and often the whole is found useless, and new material has to be used. The latter covers the liability paid for, and yet the books will show the actual cost of the experiments, which, proving useless, are discarded, and which the company will pay for unless the additional expense can be pointed out. The same remark is equally true with nearly all machinery, so that it is not safe to accept the construction account without verification.

This element of depreciation is fair and legitimate, and one which, in the settlement of a loss on a special hazard, should not be lost sight of. It is a depreciation for which there is no regular per cent., but whose value must be had from the material used and labor expended, and can only be ascertained from the books or from a judicious examination of the owner.

PLANING MILLS.

Dropping generalities, allow me to call your attention to

specific cases of cost and depreciation. First, Planers—Under this head we include tonguing and grooving machines, surfacers, and matchers. Of these there are over 300 different varieties—the Daniels planer alone has 19, planing stuff from 7 feet to 50 feet, and costing from $200 to $800. The Wendworth patent carries 20 varieties, at prices ranging all the way from $700 to $1,500. Ordinarily, a discount of from 20 to 25 per cent. is allowed from list prices. To this must be added transportation and setting up. The latter will cost from $5 to $20, depending upon weight of machine and locality in which it is placed. These machines are sold with or without counter-shafts, the latter adding to the cost of the machine from $10 to $20. The wear of these machines depends largely upon the kind of work done. If run continually on hard wood the cost of keeping them in repair would be nearly 8 per cent. of their cost annually. If soft wood, 5 per cent.

This is on the basis of having them run by competent hands. A careless hand will do poorer work and increase the depreciation from 2 to 5 per cent. The ordinary repairs are confined to replacing the knives, which cost from $8 to $20 per set, rebabbitting the boxes, putting in new springs, rubber or coil, and replacing the bed plate. With fair usage a set of knives will run, in hard wood, six months, and soft wood, nine months, before replacing. Common planing knives are worth about 10 cents per inch in length. Drop-sliding knives, $2 to $5 each. Matching tools, $2, and panel knives, $5 to $30 per set. All the boxes in a planer can be rebabbitted at a cost of from $4 to $8. By constant use the bed plate wears uneven, and will need replaning. This will occur in six months, and then again it may not be needed in two years. The cost of replaning is from $5 to $10. To the above repairs at least 2 per cent. should be added for accidents, as a planer, when once materially injured and repaired, suffers a depreciation both in its market and real value, which is not compensated by the repairs. After all necessary repairs are kept up sufficiently to do the work, there is a general wear of the entire machine. The journals, rolls, wheels, bed plate, and all parts of the planer suffer a gradual wear from friction; and although they may be keyed, returned, and tightened up, the depreciation still goes on. This is further seen when we know that the pulleys make from 800 to 1,200 revolutions per minute, and force from two to six knives into the surface of the lumber being planed at every revolution. As a general rule, the life of a planer, kept at constant work during the usual hours, is about twelve and a half years, or an annual depreciation of 8 per cent. If the planer is not kept in good repair the percentage must be further increased. With regard to depreciation on planers, the estimates made by different millmen differ very widely; the figures given are, in my opinion, as low as the facts will admit.

SHAFTING, HANGERS, AND PULLEYS.

Shafting, as usually made, varies in diameter by one-sixteenth of an inch. The average diameter ranges from 2 3-16 to 7 2-16 inches. An examination of the net costs gives us the following approximate rule, depending upon the geometrical proposition that "areas of circles are to each other as the squares of their diameters." A shaft 2 3-16 inches in diameter, turned, polished, key-seated on a prepared hanger for couplings, is worth 50 cents per lineal foot. The cost of any given size larger than this is found by multiplying the square of the diameter by 50 and dividing by the square of 2 3-16. As both numbers are given in sixteenths, the result is easily obtained.

Hangers for shafting depend for their cost upon their diameter and number of inches drop or projection. They are of four kinds—drop, post, floor, and pedestal—and vary in price from $2.50 for a 2 3-16 and 8 inch drop to $20 for a 6 3-16 inch in diameter and 18 inch drop.

Couplings vary in price with their diameters. A 1-inch coupling is worth $3.50 and a 4-inch $22. These prices are for the best kind of self-adjusting double-compressed couplings. Loose collars range from 40 cents for 1-inch to $3 for 4-inch.

Plain pulleys depend for their cost upon the face and diameter. An average price is 2 cents per square inch of the face of the pulley. Having the diameter and face given, the cost is found by multiplying the diameter by 3·1416, and that product by the width of the face; the result is the area, which, multiplied by 2, gives the cost in cents. A fair price for putting up shafting, including lining, leveling, and placing the pulleys, is $2.50 for each hanger. The difference in diameter of the shafting makes but a slight variation in the price, as it simply affects it as a matter of weight in handling.

Hangers cost to put up from 25 cents to 75 cents, depending upon their size and location. The depreciation by wear and other causes depends upon the distance the hangers are apart, the weight of the pulleys, kind of lubricators used, and the prevalence of dust and dirt in the room. In addition to these, the depreciation is increased 20 per cent. if the pulleys are worked from one side of the shaft, owing to the pressure being all on one side of the hangers.

As a general rule in iron workers, 3 per cent. is a fair annual depreciation and 5 per cent. in wood workers. There are so many factors entering into the wear and tear of shafting that no rule will apply in all cases. With rigid bearings a very trifle out of line, the wear on shafting and boxes may be doubled. Using cheap lubricants containing gritty particles, as are sometimes found in earth oils, rapidly cuts away the bearings and depreciates the value of the shaft. These are items which the surveyor would do well to notice, when fixing values or estimating the fire-hazard, as a combination of a part or all of them not only causes a rapid depreciation, but enhances the fire-hazard.

(To be continued.)

COMBINED DREDGER, TUG, AND FIRE ENGINE.

THE Calcutta Port Commissioners some little time ago called on their engineering agent, Mr. W. F. Batho, of Westminster, to design for them a vessel which should combine in one a dredger, tug, and fire-engine for the use of their harbor; and the result of this request has been the construction from Mr. Batho's plans of the vessel and apparatus of which we publish engravings opposite. The vessel with her machinery has been constructed by Messrs. Hawks, Crawshay & Sons, of Gateshead-on-Tyne, and her principal dimensions are as follows: Length, 180 feet, moulded breadth, 22 feet 6 inches, and depth 10 feet; her mean draught is about 6 feet, giving approximately a displacement of 370 tons. She is divided into seven water tight compartments by six transverse bulkheads. There are two pairs of independent engines driving twin screws, the same engines being used to actuate the dredging machinery and the fire pumps.

We will first describe the engines, boilers, and fire-engine pumps, and then refer to the dredging arrangement, which certainly is the boldest departure from ordinary practice we know of in this class of machinery. Each pair of engines is of the inverted tilt-hammer type, the two pairs being placed back to back, their vertical center lines converging toward the top. They are duplicates, and are perfectly independent, the surface condenser placed between them being the only part they have in common. They are compound engines, with intermediate receivers and cranks at right angles, and have the air, circulating, bilge, and feed pumps driven by bell-crank levers fixed at one end, and connected by links to the piston-rod crossheads at the other end. This arrangement was adopted to save room, the available space being very limited; it of course has the disadvantage of leaving the weight of the pistons, piston-rods, and connecting-rods unbalanced. The cylinders are 15 inches and 27 inches in diameter, and 21 inches stroke, working with 70 lb. steam pressure, at 110 to 120 revolutions per minute. The engines are rated by the makers at 30 nominal horse-power each, and are capable of indicating up to 170 horse power each, or a total of 340 horse power, which it is expected will give the boat a speed of 10 to 11 miles per hour. The cylinders are not jacketed, the high pressure slide-valve is placed on the forward side of its engine, and the low-pressure valve between the two cylinders. The surface condenser has ¾ in. brass tubes, packed at both ends with screwed glands, and has a total surface of about 600 square feet. The air and circulating pumps are each 10 inches in diameter by 10½ inches stroke, the feed and bilge pumps being each 3 inches in diameter, and the same stroke. The propellers are of cast iron, 6 ft. 6 in. in diameter, with a mean pitch of 8 ft. 6 in. There are two boilers, each 8 ft. 3 in. in diameter by 8 ft. 6 in. long, each containing two 2 ft. 6 in. furnaces, and 90 3-inch tubes; the total grate area is 43 square feet, and the total heating surface 1,200 square feet. The furnaces and combustion chambers are made of Ridsdale iron, a brand which we are informed has uniformly given most satisfactory results when used in such situations.

The fire engine pumps are placed forward of the main engines, and are driven by spur gearing by the starboard engines, at half the speed of the latter. They are each 12 inches in diameter by 18 inches stroke, and are placed vertically on their standards over the cranks which drive them. They both deliver into a wrought iron air vessel, from which there are connections for four hose.

The port main engines are used for working the dredging apparatus, and put in motion the hydraulic pumps which transmit the power required for raising the material, and the air pump which generates the necessary pressure for discharging it to a suitable position on shore through hose pipes from the receiving tanks into which it has been temporarily deposited. The dredging gear consists of two of Bruce's patent excavators, each capable of containing about 5 tons of stuff, these buckets being hemispherical in form, and so constructed as to open in three sections and dig into the ground, and then to close and grasp the load they are intended to raise. The whole of the motions of raising and lowering the buckets, as well as of opening and shutting them, are performed by hydraulic pressure.

Referring to the engraving opposite it will be seen that the buckets work through two wells in the vessel, and part of the lifting and lowering motion is given by pistons working in hydraulic cylinders carried at the extremities of a vibrating beam to which oscillating motion is also given by two other vibrating hydraulic cylinders taking hold of the beam at points between its center and the points of suspension of the hydraulic cylinders placed immediately over the buckets. It will thus be clear that when one bucket is in its highest position delivering its load into the shoot, the other bucket is at the bottom receiving its charge; and from this arrangement it is evident that the whole of the machinery is perfectly balanced, the only resistance to be overcome being that due to the weight of the load plus the friction. Inside the piston rods of the outer cylinders, carried on the ends of the beam, there are smaller hydraulic cylinders giving the opening and closing motions to the three jointed sections of the digging buckets. Two mud receivers are placed athwart ships between the center of the main vibrating beam, and the two wells through which the buckets work, each having a capacity of 1,250 cubic feet, and estimated jointly to contain 100 tons. The wells are provided with suitable doors at the bottom, capable of being closed when the vessel is towing or moving from place to place, so as to lessen the resistances which would otherwise be caused by eddying currents.

The hydraulic cylinders at the ends of the beam are carried on gimbals, to allow for the irregularities of position the buckets may assume, owing to the nature of the bottom, and immediately above the points of suspension of the links controlling the opening and closing of the buckets, are fixed crossheads, placed athwartships of the vessel, carrying chains at their ends, which, when the buckets are rising, elevate shoots fixed at one end. These shoots follow the buckets up until they are in their highest position, by which time the free ends of the shoots are over the mouths of the receivers, into which the material which has just been raised is shot, by depressing the smaller internal hydraulic piston in the cylinder at the end of the beam, and so opening the digging bucket, and allowing it to discharge its load. As in the trials we lately witnessed of the apparatus, some little difficulty was experienced in getting the shoot to rise nicely, owing to the line of pull of the chains used for elevating it being nearly in line with the centers round which its fixed end swung, we understand it is contemplated to add counterbalances to make the shoots work more smoothly.

The hydraulic pressure used is 700 lb. per square inch, and is generated by means of two pumps, worked direct from the shaft of the port main engines. These pumps have barrels 3½ inches in diameter, with piston rods 2½ inches in diameter, and have a stroke of 18 inches. As it is not advisable to have these pumps directly coupled on to their work, a steam, as well as a spring accumulator is used, it being out of the question to employ an ordinary weighted accumulator, owing to its weight, height, and bulk. The steam accumulator consists of a cylinder 30 inches in diameter, working direct on a ram 10 inches in diameter, both having a stroke of 4 ft. 9 in. The spring accumulator has a ram 6 inches in diameter and 12 inches maximum stroke; it is loaded to 1,000 lb. by sixteen volute springs surrounding four columns placed on a plate on the head of the ram.

The addition of these two accumulators was found to be very beneficial in working, as it permitted the storing up of a small quantity of water to come and go on; in attempts made to work the dredger before they were introduced, it was found almost impossible to regulate the main engines which were driving the hydraulic pumps.

The pipes connecting the latter with the working cylinders are 3½ inches in diameter, and they are fastened to a kind of Y piece, bolted on to the main vibrating beam, having the tail concentric with the main gudgeon of the beam and provided with elbow swivel joints to allow for the motion of the beam; the connection to the hydraulic cylinders placed at the outer ends of the main beam, which it will be remembered are carried on double gimbals in order to allow these cylinders motion in two planes, is also made by swivel elbow joints. We fear these joints may in practice be found liable to give some trouble, and think it would have been a preferable job to carry the water connections directly through the main beam gudgeons as well as through the trunnions of the gimbals carrying the outer hydraulic cylinders.

On September 18th we witnessed some trials made with the dredger in the Tyne, and in the annexed table we summarize the results obtained.

DETAILS OF TRIAL OF BATHO'S PATENT HYDRAULIC DIGGING DREDGER, AT NEWCASTLE-ON-TYNE, SEPTEMBER 18, 1879.

Number of Lift.	State of Bucket.	Time.	Place of Discharge.	REMARKS.
1	One-third full.	10.46	Part in receiver.	These first six lifts were all sent overboard owing to the want of practice in working the controlling valves, the shoot accidentally being lowered at the same time the digging bucket was opened.
2	Full.	10.48	Overboard.	
3	"	10.51	"	
4	"	10.53	"	
5	"	10.55	"	
6	"	10.57	One-third in receiver.	
7	"	10.59	All in receiver.	
8	"	11.01	"	
9	Empty.	11.0¼	—	Digging bucket had emptied hole under ship, which was stationary. After twelfth lift dredger was gradually moved so as to allow digging bucket to get hold of fresh stuff.
10	One-third full.	11.03	Receiver.	
11	Empty.	11.05	"	
12	"	11.06	"	
13	One-third full.	11.08	"	
14	Full.	11.09	"	
15	"	11.10½	"	
16	Empty.	—	—	Digger failed to close.
17	Full.	11.13	Receiver.	
18	One-third full.	11.14½	Overboard.	Stopped to pack pump gland.
19	"	11.18¼	Receiver.	Position of dredger not shifted close astern of another vessel.
20	One-half full.	11.20	"	
21	Very full.	11.21½	"	Hydraulic cylinder assumed a considerable angle.
22	"	11.23¼	"	
23	One-half full.	11 25	"	Lump of coal stopped digger closing.
24	Full.	11.26	"	Stopped digging.

NOTE.—The bottom of the river where the trial was carried out was covered with large and small lumps of coal, ropes, and pieces of rubbish, which often prevented the digger closing properly when they got between the edges. The edges were, however, so tight that the digger would hold water when they were allowed to come closely together.

During these trials only one digger, the after one, was at work; the ground was clay, with mud at the top. The twenty-four lifts were made, as will be seen from the annexed table, in forty minutes, or say, at the rate of thirty-six per hour, or seventy-two for both diggers, and taking each discharge equal to 5 tons, this gives a total delivery of 360 tons per hour. When the digging trial was ended it was attempted to force the mud out of the receiver by air pressure in accordance with Duckam's patent system, but as the pressure could not be raised above 5 lb. per square inch, owing to some leakage, it was found impossible to empty the tank by this means. Considering the dredger is to work in Lower Bengal, where all kinds of earthwork can be so cheaply carried out by cooly labor, we very much doubt whether it would not have been more advisable to have arranged to let the mud be delivered direct into barges; by this means the dredger could have been kept continuously at work instead of spending part of its time going backwards and forwards between its work and the spoil banks. Less time would, we believe, be lost by a dredger of this description than by ordinary ones in maneuvering about to take up its position, owing to its being provided with twin screws, and there will also be less strain on the moorings tending to displace them, as the action of the digger is vertical, and not oblique like that of a common dredging ladder, which is naturally always tending to push the boat out of its place, and causes great loss of time in getting exactly into position, and particularly when cutting in narrow channels or confined places. The chief difficulty, we fear, with the present arrangement of the plant will be caused by the

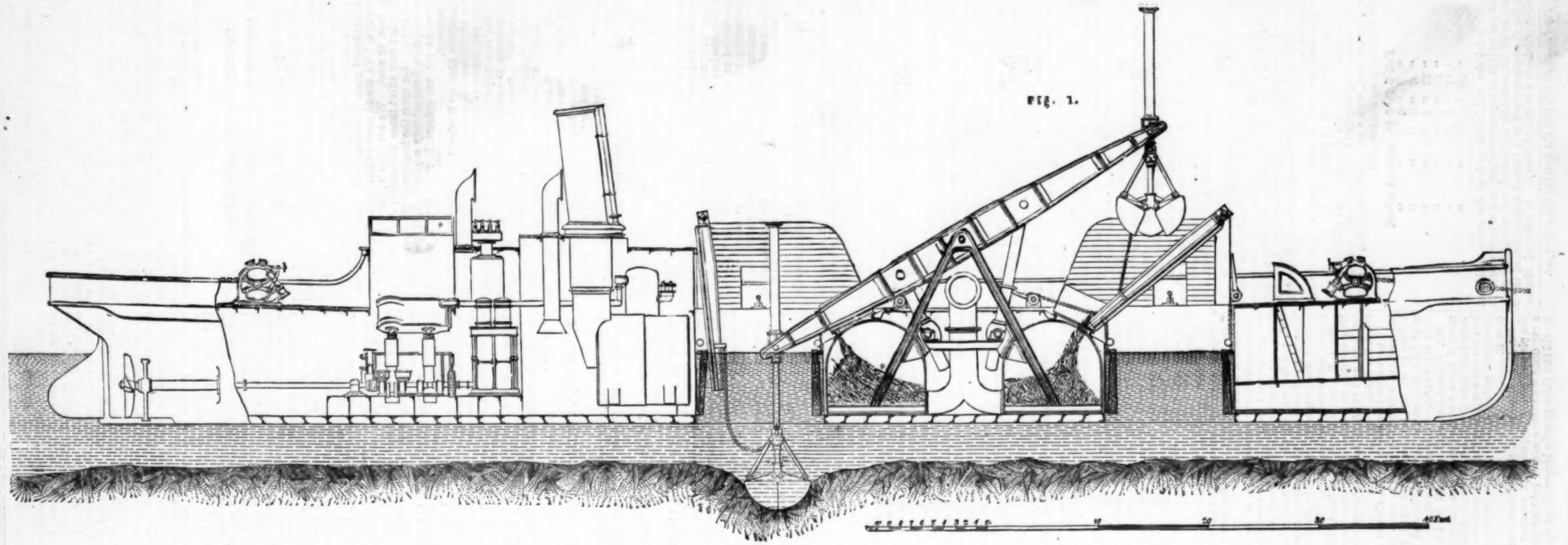


Fig. 1.

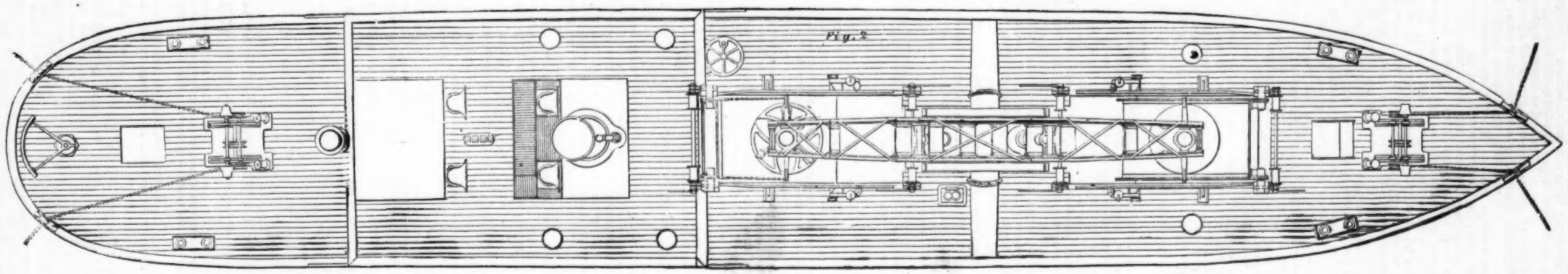


Fig. 2.

COMBINED DREDGER, TUG, AND FIRE ENGINE.—CONSTRUCTED BY HAWKS, CRAWSHAY & SONS.—DESIGNS BY BRUCE & BATHO.

wear of the packings in the outer hydraulic cylinders over the diggers, due to dirt settling on the piston rods, which are of course naturally greasy, and dripped down each time a lift is made into the water, which of course is full of dirt or grit stirred up by the digging. This objection can, however, be easily overcome in future. Altogether, we think the design from its simplicity and direct action one of great promise, getting rid as it does of all the wear and tear and friction unavoidable in the old system with the ladder and buckets, and having the advantage of having all its own working parts perfectly balanced. Great credit is due to Mr. Batho, the engineer, for the boldness of his design, as well as Messrs. Hawks, Crawshay & Sons, the makers, for the very great care they have bestowed upon the construction, as well as for the quality of the workmanship and materials.—*Engineering.*

TOUGHENED GLASS SLEEPERS.

ON THE APPLICATION OF TOUGHENED GLASS TO PERMANENT WAYS.*

By C. WOOD, M. Inst. C.E.

I HAVE pleasure in laying before you some details and specimens of an invention which I am sure will be looked upon with considerable interest, not only from its great novelty, but because it may have some effect upon the iron industries of this and other countries. I mean the application of toughened glass to sleepers and chairs for railways or tramways. We are all more or less interested in the success of iron or steel. We are also equally interested in anything that may affect those industries; and, without expressing any opinion upon the toughened glass as applied to railway purposes, I cannot help saying that, if the particulars given to me are correct, it must have a wonderful future before it.

Mr Hamilton Lindsay Bucknall, Associate Inst. C.E., the inventor of this new application, has kindly given me the following particulars concerning his glass sleepers.

The glass is moulded into various forms to suit the different requirements, the cooling of the glass being so regulated that the radiation from each point of the surface corresponds to the thickness of the glass, thus enabling the casting to be equally affected throughout when undergoing the tempering or hardening process. The regulation of the radiation or absorption of the heat in the thicker parts of the casting is done by having iron moulds hollow, and by circulating cold water or cool air at those points where the glass is thickest, so that the casting cools equally all over.

The mode of toughening the glass is both curious and instructive, affording as it does a complete contrast to that of steel. The glass is heated to a high temperature and then plunged into a bath of cool oil or other liquid, the result being that the glass becomes converted from its own characteristic brittleness to the remarkable tough fibrous material known as toughened or tempered glass, but to produce the desired effect and obtain the full advantages of the toughening process, upon articles of great strength and thickness, Mr. F. Siemens has found that the hardening or tempering can be effected in the moulds themselves: First, by carefully protecting the glass from coming in direct contact with the metal mould, to prevent the chilling of the surface of the glass; and secondly by the use of the hollow moulds before spoken of, for maintaining a uniform temperature all over the casting during the hardening. The temper is modified in these thick castings by passing them through an annealing oven.

The moulds are chiefly protected by layers of wire gauze, perforated metal, or plaster of Paris, varying in layers or thickness according to the rapidity and energy required in tempering, with the nature and composition of the glass—this energy being increased at the thick parts of the casting before alluded to, by the circulation of cool water or air through the cast iron hollow mould. So far as experience has shown, all kinds of glass are equally affected by the process.

The toughening process as well as the hollow moulds are the patent of Mr. Frederick Siemens, of Dresden, and recently brought by that gentleman to great perfection by the simple and inexpensive means above alluded to. The first cost of this specially prepared material will not exceed that of cast iron, but the specific gravity of glass is only one-third that of iron, and its strength for all practical purposes is as great. A large output is anticipated, and in this way it is calculated that the first cost of glass will be considerably less than that of iron; and by a similar calculation can be shown to be cheaper than wood. It is asserted that these glass sleepers will, as far as one is able to judge, last a very long time, being neither subject to corrosion nor decay. Under these circumstances, it will be unnecessary here to enter into any calculations to prove the enormous saving that will be effected in the maintenance and renewal of permanent ways. Such a fragile material as glass has hitherto been looked upon as useless for purposes where great strength is required; but impossible as it may sound, the toughened glass is almost as strong as iron, while it possesses greater durability. Its qualities certainly deserve a fair trial and investigation, and the time may come when we shall see not only glass sleepers, but glass tools and implements, eaves troughings, or spouting, for furniture, and many other things.

Some of these glass sleepers are laid down upon the North Metropolitan Tramway. They are laid longitudinally in 3 ft. lengths 6 inches by 4 inches, and are specially formed on the upper surface to allow of the rail exactly fitting. The average transverse resistance of the sleepers, tested at Mr. Kirkaldy's works, in Southwark, supported at 30 inches, was found to be about 5 tons.

The following are results of tests carried out at the works of Mr. William Henderson, of Irvine, N. B.

A falling weight of 9 cwt. dropped from a crane upon a glass plate 9 inches by 9 inches by 1½ inch laid upon gravel ballast 9 inches deep, with a wood cushion ¼ inch in thickness between the glass and the rail:

Fall 3 ft.	0 in.	without	effect.	
" 5 "	6 "	"	"	
" 7 "	0 "	"	"	
" 12 "	6 "	"	"	
" 15 "	0 "	"	"	
" 17 "	6 "	"	"	
" 20 "	0 "	"	"	

At this point the rail broke, and as the crane could not elevate the weight to a greater height, and a heavier weight was not available, a smaller section of rail was substituted, when the glass succumbed to a second application of the 9 cwt. dropped from a height of 20 feet. A series of similar experiments were made upon this occasion with more or less the same results. A ½ in. cast iron plate 9 inches by 9 inches by ½ inch, tested in the same manner and under similar circumstances, broke with a drop of 10 feet. Several samples and specimens are upon the table. Amongst which is a bowl sleeper, also a buckled plate for floors.

Mr. Bucknall proposes to make these sleepers out of blast furnace slag, under Mr. Bashley-Brittain's process, combined with the toughening process of Mr. Siemens. After describing to the writer the difficulties he has had in getting his experiments carried out in England, the inventor mentions, among other things, that the glassmakers to whom he applied would not undertake any experiments unless all expenses were paid, and that these manufacturers would not make the moulds or presses for the process, but recommended other firms. On application to the pressmakers, however, he got a quotation asking between £70 to £80; and it was stated that it would take three months to invent, and that he must be responsible for any extra charges made. Under these circumstances, he says: "I gave up in despair; but having casually heard of the Siemens process, I got an introduction, and was put in communication with Dresden, and within a week found myself at the glass works of Mr. F. Siemens in that city. In another week a wooden model, which cost 2s. 6d., was produced, and an iron mould made from it which cost about 30s.; and two days afterward I held in my arms the first baby glass sleeper; but so heavy was this first-born, that it suddenly slipped from my grasp and fell with a heavy thud upon the flags. I feared for the safety of my darling's carcass, but upon careful examination, I found it to be unimpaired. There its longitudinal form lay upon the ground, not dead, but a veritable sound sleeper, still living, and probably worth more than a dozen dead ones."

Whether Mr. Bucknall succeeds in making railway sleepers or not, if this toughened glass be really as sound and good as is claimed, it must succeed for numerous purposes. We must learn to look upon all new things with a liberal spirit, knowing as we all do the exertions of a single individual in condemning a good thing usually reverts upon his own head. I am sure of one thing, that Mr. Bucknall's invention can do me no harm, and I wish him as much sucess with his glass as I have had with my wrought-iron sleepers upon the North-Eastern Railway. There is plenty of room for us all.

* Paper read before the Iron and Steel Institute at Liverpool.

PAINTING, VARNISHING, AND CLEANING OF CARS.

AT the recent annual meeting of the Master Car Painters' Association the regular topics for discussion were as follows:

1. *The best method of cleaning cars, inside and outside, preparatory to varnishing.*

Mr. H. M. Billings, of the Pitts., Cin. & St. Louis road, said that the old method of cleaning with ordinary soap had been nearly abandoned, and a variety of new agents employed, but care and discretion were required in their use. The plan of rubbing down with ground ramie stone and water had to be given up on account of the use of coal for engine fuel. The cars got begrimed with dirt and smoke, so that when they came in for revarnishing it was impossible to clean them in this way. A very effective compound which he had used with success was as follows: 10 pounds sal-soda, 3 pounds white Castile soap, 1 quart ox-gall, and 20 drachms starch, although the latter ingredient was not essential. Another excellent mixture, which formed a thicker compound than the other, was 10 pounds sal-soda, 10 pounds common brown soap, and 8 ounces each of borax, salts of tartar, and ammonia. This was reduced with water to suit the kind of work, from a head lining where great care is necessary in washing, to the dirtiest job that came into the shop. After washing, rub down with ground ramie stone, and wash well with water, so as to remove all the alkali before applying the varnish. Mr. Billings thought that all master car painters should become better acquainted with the principles of chemistry.

Mr. D. C. Cooley, of the C. B. & Q. road, expressed his preference for soft soap as the only reliable cleaner. He had tried compounds of various kinds, but considered soft soap, when used with proper judgment, as the best.

In the course of the discussion, nearly all the members stated their views, the majority of them giving soap and water the preference, as being a quick method of cleaning, and with no bad results if proper care was used, and the work rubbed with ramie stone before varnishing.

2. *Which will wear longest, two coats of hard rubbing varnish and one of wearing body, or one coat of hard rubbing and two coats of wearing body?*

Mr. A. N. Bradley, of the Ohio & Miss., thought that wearing varnish gave the best results; rubbing varnish was detrimental to the wear of the paint; it being a hard drying substance, it had a tendency to crack when an elastic varnish was put on over it. He sometimes used rubbing varnish in the last two coats of finishing color, which dried with an egg-shell gloss; this answers as a drier in place of the Japan.

Mr. R. McKeon, of the Atlantic & Great Western, had done work both ways, but believed, from late experience, that two coats of wearing varnish on a flat color was the best; he believed it would do away with the cracking of the paint, as undoubtedly the excessive use of hard rubbing varnish was the cause of most of our cars cracking; the only objection to the wearing varnish is that a good surface cannot be had, and the first coat of varnish is inclined to enamel, although he believed the use of the varnish in the two last coats of finishing color, which Mr. Bradley uses in place of Japan, may remedy the evil.

Mr. J. B Cox, of the Eastern Road, did not use any rubbing varnish, as it dried harder than the paint under it, and the paint and finishing varnish being both elastic, it must crack the work.

In answer to a question by Mr. Cooley, Mr. Bradley gave his mode of mixing the finishing coats of color; he did not believe in oil, but just enough to bind the paint; varnish must protect it, and it was not intended that paint should have any wearing qualities in itself.

Mr. McKeon had used more oil in his color coats than most of those who had spoken on this question. His reasons were that there should be a body to hold out the varnish, and the color mixed in this way was also more elastic, and therefore better suited to the wearing varnish applied over it.

Mr. C. E. Bradley, of the Pullman Car Works, opposed the plan of giving two coats of wearing varnish. He said a car done with two coats of rubbing and one of wearing would run three months longer, clean up better, and the results be more satisfactory all through; if the wearing varnish had a sufficient time to harden before going out, it might do equally as well, but time was limited, and very few shops could hold the car the necessary time to harden between coats.

The subject was discussed by every member, and the president, Mr. D. D. Robertson, in his remarks, thought that the wearing varnish had the preference; but time was necessary, because the longer time between coats gave a better gloss and harder finish, but often we were obliged to get work out quickly, and it was then economy to use a quick drying varnish.

3. *What is the best method of cleaning cars coming in in winter covered with ice, sand, and ashes?*

There was considerable discussion on this question, but the only opinion arrived at was to take the cars in a warm shop and thaw them off.

4. *The best size for gilding and working easily.*

The discussion upon this topic made it evident that good Japan gold size, tempered with rubbing varnish, was the best for outside work, and when tempered with oil, was best for a slow size, which was mostly used on inside gilding and on head linings where no varnish was to be applied over it. It was generally conceded that any gold size which was to be varnished over after gilding should dry hard, or about as the coats of paint dried under it, and if not hard, it would be liable to crack when varnish was applied over it.

5. *Are head linings injured or improved by varnishing?*

The discussion brought out the methods adopted by nearly all the members. A majority varnished linings, but the varnish was not used clear; some reduced it with turpentine, others used damar and wax, the object being to get as little luster or gloss as possible, and still protect the lining from injury when it became so soiled with dirt and smoke as to require a strong soap or alkali to clean it.

6. *The best mode of painting and finishing a car body with a view to economy and durability.*

Mr. C. E. Bradley, of the Pullman Car Works, gave his practice in detail. He used raw oil in priming coats, and boiled oil in all the following coats: two coats of rubbing varnish and one of wearing body. Other members used boiled instead of raw oil; others less oil and more turpentine, and generally with fair success. Several speakers advocated the keeping of a record of every car painted, with notes of the methods used, as giving an opportunity to make intelligent tests. Others referred to the necessity of allowing full time for the priming coat to dry, if durability was desired.

7. *The best drier, and the best mixture for head linings.*

For a head lining mixture, some used glue and starch, others boiled oil for first coat. Mr. Wm. Davis, of the Canada Southern, exhibited a sample of cloth prepared with a composition of which molasses was the principal basis. Various recipes were presented, for all of which were claimed elasticity and good results as to wear and freedom from cracking. Mr. Bischoff, of the Chicago & Pacific, believed red lead and litharge to be the best drier, and more reliable than any others in the market, if used in proper qualities. For general car painting, Japan gold size had the preference, and most railroad shops were using it; its qualities were good, it dried elastic, and would not break in the drying. It was of the same nature as varnish.

8. *The best and most economical style of ornamentation for head linings.*

The beg, borrow, and steal style was advocated. There was little that was new in this line of ornamentation. It was the aim to have it in keeping with the interior finish of the car, by avoiding unseemly and violent contrasts. Mosaic and Eastlake were coming into use, but these styles were expensive, and made comparatively little show. Head linings now cost on an average $75 per car.

9. *The most economical and durable color for the outside of cars.*

Mr. Davis, of the Canada Southern, read a paper advocating the use of light colors. Most of the members concurred with him. Some would have a clear white, but the lighter the color the more durability. It was less affected by the heat of the sun, while dark colors showed defects more readily in the finish. Light colors required less varnish, but it was admitted that striping could be done on dark colors on a single coat, while light ones required for striping two or three coats. It was of little use to discuss the subject, however, as the corporations in most cases decided the color for themselves, without regard to its durability or the opinion of car painters.

10. *The best mode of painting over old paint.*

Mr. Wm. Sharp, of the Lake Shore road, said in cases of old and cracked paint, very few thought it was economical to paint over such work, as it would blister after being out. But if it must be done, the varnish must first be killed by a solution, or rubbed down close, and if there were cracks, give the car a scraping filler, somewhat elastic.

Mr. Stow experienced great difficulty on account of blistering, but remedied the evil by a coat of oil drier and "turps," mixed, letting it stand six or eight days, which raised the blisters. He rubbed the old varnish down close, and gave it a coat of half and half oil and "turps;" when there were old cracks he would give the car a scraping.

Mr. Will deprecated the use of water, as it would dry out. He killed the varnish with an alkali and then rubbed it down, but it cost almost as much as to burn it off.

Mr. Cooley did not approve of painting over old paint, and when he did this always called it revarnishing. Some cars thus repainted stood better than others, but he had given up the idea of doing a good job in this way.

Mr. Bradley used caustic soda to remove the old varnish and followed up with lump pumice stone, then adding a thin coat of varnish, a coat of flat color and three coats of finishing color. Blistering was not always the fault of the painter. He had opened blisters from which the water ran out, the trouble being in the use of green lumber, from which the sun drew the dampness.

Other members followed, generally expressing the opinion that the practice of painting over old paint should be abandoned as rapidly as possible.

The next year's meeting will be held in St. Louis. The officers of the association are: D. D. Robertson, Mich. Central, Detroit, Mich.; J. H. Will, New York & Harlem, Morrisania, N. Y.; R. McKeon, Atlantic & G. Western, Kent, Ohio.

BELL FOUNDING.

THE Ipswich (England) *Journal*, in describing a peal cast for Weybread church, refers as follows to some innovations in fixing bells:

The old timber framework was removed, and has been superseded by a framework entirely new, and composed, with the exception of the bell-wheels and rope-pulleys, of iron. The clumsy, ponderous oak beams, which form the bell pits, and which are generally to be seen in churches, are supplanted by a strong iron framework, much lighter and more simple looking. The frame is based upon two iron girders, and the smaller bells are hung above the larger ones. The girders support iron strains, which in their turn support the stocks on which the small bells are suspended, and on the lower flange of the girders rest similar but shorter strains, which support the larger bells, hung beneath the others. The girders are braced together with tie-rods, and cross-pieces so firmly hold the whole framework together that it is perfectly rigid, and none of the motion noticeable in the ringing of bells in the old wood framework is to be seen. The framework is entirely new to the majority of people, but in that respect it is not unique, for there is at present another iron framework in existence. But what makes it unique is the fact that the whole of it, with the exception of the stocks, is composed of wrought iron, while the other frame mentioned is of cast iron. With all the advantages of the new frame, its cost is no greater than the old ones. The bells themselves differ from others in several respects. The founders had, by careful study of the best old bell-founders of the country, nearly succeeded in casting a maiden peal (bells which come from the foundry and need no trimming to bring them to the right tone are called maidens), but numbers 3 and 4, the last ones cast, were, by an error, made just a trifle flat. The amount which these two bells were out of tone was so slight that it was contemplated to put them up as they were, but they were sharpened to the proper tone, and the peal, therefore, has four maiden bells. The method of attaching the bells to the stocks is quite new. Instead of the cannons generally used, let into a heavy block of wood which forms the stock, there is a mushroom-shaped top which is extended into the stay, and fastened there by a bolt, and when the bell is up for ringing the stay rests on a swing slider which it can press a few inches on either side when resting on it, and in that manner the bell is supported when up, and this, also, is entirely new. The stock is a great improvement. In the place of the great wooden blocks to be seen in other churches, a cast iron bar is used, and instead of embedding the top of the bell in it, as is done with large bells with wooden stays, the stock is curved in greater or lesser degree, according to the size of the bell. The great feature of the bells, however, is the clapper, which is constructed in such a manner that, after striking the bell, the clapper does not remain on the side of the bell. This has been attempted before, but the plan having been tried by means of springs it has failed. The plan adopted by the Redenhall Company is a simple one. The shank of the clapper is a hollow tube which slides on an iron arm. The shank slides on the arm for about three-eighths of an inch, and the centrifugal force of the bell's swinging throws the clapper out to the end of the arm, and it thus strikes the bell; the shank then falls by its own gravitation back to the other end of the arm, and then the clapper rests on a cross-piece at the top of the bell, and the striking part of the clapper is about an eighth of an inch from the side. The clapper is made of a softer metal than the bell, and this, besides improving the tone, prevents the clapper from wearing away the side of the bell; but the clapper, which is easily repaired, wears by its action. This attempt is undoubtedly the most successful that has been made to keep the clapper from resting on the side of the bell. Instead of swinging with gudgeons on bearings, as is usually the case, the ends of the stocks of these bells serve as gudgeons, and work on friction wheels or roller bearings. Another feature of these bells is that by striking the bells in the waist each one gives its note in major 3.

MONCKHOVEN'S PHOTOMETER FOR THE STUDIO.

WE have received from the editor of the *Bulletin Belge* Dr. Van Monckhoven's description of the instrument, of which we give a translation below:

Dissolve 100 grammes of uranium nitrate in 200 grammes of water; pour the solution into a porcelain basin, and heat it over a Bunsen burner; add gradually a hot concentrated solution of ammonium carbonate and water, when a brisk

effervescence, caused by the disengagement of carbonic acid gas, will occur, and a yellow precipitate of uranate of ammonia will be formed. Continue to add the ammonium carbonate, and the precipitate will be redissolved, until the liquid becomes quite clear. This is owing to the uranate being soluble in an excess of ammonium carbonate. Now leave the solution to cool till the next day, and the bottom of the basin will then be found to be covered with crystals of the ammonio-carbonate of uranium; these crystals must be lifted out, placed on a piece of blotting-paper, and dried slowly in a drying oven. Then make a solution of 30 grammes of oxalic acid in 200 grammes of water, put 50 grammes of this salt of uranium into it, and shake the mixture. The uranium salt dissolves with the evolution of carbonic acid, and uranic oxalate is formed; this must be filtered into a flask, A (see fig.), made to hold exactly 250 grammes, and the flask is then filled up to the neck with water. Into the neck of the flask is fitted an India-rubber cork, B, which is pierced, and carries a tube, C D, about 30 centim. in length. When the cork is pressed down in the neck the liquid rises to the point, G; in order that it may do so the lower end of the tube must project a little beyond the bottom of the cork, but not to a greater distance than one or (at the most) two millimeters. The tube must also be furnished with a movable scale on paper, graduated to centimeters and millimeters. If the instrument is to be used as a photometer for the studio, the bore of the tube must be one millimeter in diameter, but for the carbon process it should be four millimeters.

As the liquid is affected also by heat, the instrument must be left for some time in the place where it is to be used, in order that it may have the same temperature. To prevent the light from acting on it, it may simply be kept under a cardboard shade. So soon as it is exposed to daylight the liquid will be seen to rise in the tube, and if the light be strong, and the tube, D C, vary narrow, it will reach a height of several centimeters in less than a minute. If the flask have a capacity of half a liter, and the bore of the tube be one millimeter in diameter, the action will be so rapid that the reading may be taken at the end of thirty seconds. As the color of the solution is rather of a pale green, it may be made stronger by aniline violet, which will enable the liquid to be easier seen in the tube.

The action of the apparatus is as follows: Under the influence of light the uranic oxalate is converted into the corresponding uranous salt, and a certain quantity of gas is liberated, which accumulates in the upper part of the flask, and causes the liquid to rise in the tube by an amount directly proportional to the action of light. To allow the gas to escape, and the column of liquid in the tube to fall to its ordinary level, it is only necessary to loosen a little the cork, B, in the neck of the flask.

This photometer possesses a very great advantage over those in use among photographers, namely, that it does away with the necessity of comparing different tints in order to read off the degree of photogenic action. If it be kept clean, by pushing an iron wire through the tube from time to time, the instrument will last a long time. In 1840, Draper pointed out that ferric oxalate could be made to serve as a photometer, and at a later period Marchand actually employed that substance with success for the purpose indicated. But the oxalate of uranium is much more sensitive than the corresponding salt of iron, though its use in that capacity has hitherto never been suggested.

"However," as Dr. Monckhoven adds in conclusion, "the question of priority is of no importance. All that I desire to point out is, that photographers can make excellent use of this instrument in the carbon process, and especially for determining the necessary length of exposure in the glass studio."—*Photographic News.*

M. JAMIN'S ELECTRIC LAMP.

M. J. JAMIN, of the Institute of France, writes as follows to *La Nature* in regard to his electric lamp: In your article of August 9, devoted to the Wilde lamp, you advise the uniting of the two systems—that of the English inventor and my own. You were not aware that I have myself made use of an arrangement which realizes the same advantages, and which possesses, in addition, features that are entirely new. This arrangement, at first glance, resembles that of Mr. Wilde, but in the main is entirely different. It resembles it in the fact that an electro-magnet is used (which is a

FIG. 1.

thing allowable in all), but it differs from it in the construction of this electro-magnet and the manner in which it is employed.

Every apparatus (Fig. 1) is supported on a circular platform of marble, onyx or slate, C E. The two carbons, *c c'*, placed in jointed holders, rise and descend along two rods, M N, one of which conducts and the other receives the current which has traversed the carbons. This current afterwards cirrulates through the gutter, C D E, making six turns therein, and by this act fixing the arc invariably at the extremity, C. The apparatus can be used by arranging the points either upwards or downwards, and succeeds with both the Gramme machine and alternate-current machines. Let us suppose that is a question of the latter. In order that the wire be bent upon itself in the gutter, C D E, six times, it must pass the same number of times into the platform, C E, as shown in Figure 2. This part of the wires, which, up to the present time, has been useless, has received a happy application. They are made to pass between the two sides of a plate of iron bent U-shape. This serves to magnetize them and produce two opposite and very feeble poles, A and B (Fig. 3). The iron must be very soft, so that it may take, before and after every reversal of the currents, opposite magnetizations. Two contacts, movable around the articulator, O, and held back by the springs, C and D, are attracted at every magnetization and undergo an oscillatory movement, which is synchronous with the passages of the currents. They are joined by two lever arms to the carbons, *c*, which assume the same motion, approaching each other when the currents cease, and separating progressively and proportionally to the intensity of the successive currents furnished by the machine. At rest, they are in contact and become lighted as soon as the circuit is closed. Such is a general description of what I call the oscillating lamp. Now let us examine its advantages.

Let us represent by a curve (Fig. 4) the intensities of the successive currents in operation at the time. These currents, on account of the resistance of the arc, only pass if they have sufficient intensity to overcome it; and are arrested when this resistance is weak. For example, one of them stops at A, and begins to circulate again and to relight the

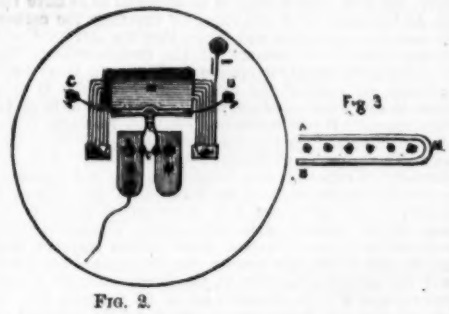


Fig 3

FIG. 2.

arc only when its intensity has again assumed at B a sufficient intensity, and which is probably greater than at A. Then during the whole duration, A B, nothing passes; then again during the duration, B C, the arc is reproduced, and so on. It is a discontinuous action, and the carbons receive only a portion of the electricity—the largest portion; but the remainder, that which is produced during A B, is entirely lost; it is so much the greater in proportion as the carbons are further separated, and *vice versa*. It is just precisely this that causes the oscillation above referred to. The carbons approaching when the current diminishes, the arc is extinguished only at A′, and is relighted at B′; the greatest part of the electricity which was lost is then employed,

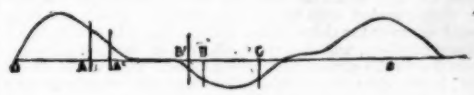


FIG. 4.

the result being a remarkable increase of light. And this is not all. The heat produced at the points results from two causes: (1) from the passage of the current (electric heat); (2) from the combustion of the carbon. I have measured the total heat by inclosing the apparatus in a calorimeter. As to the heat of combustion, it is estimated by multiplying the weight of the carbon burned by its heat of combustion per gramme. Now it has been found that the latter is considerable; with a single burner it is a third, and with seven it is half the electric heat.

This is not the time to dwell on the importance of this unlooked for fact; the only remark that it is necessary to make is, that these two carbons concur proportionally in the production of light, and that efforts should be made, not to reduce, but on the contrary to quicken combustion by means of oxygen, air-currents, or otherwise. Now the os-

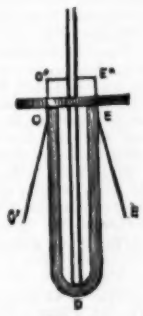


FIG. 5.

cillation of the carbon in air renews the gaseous matters that are in contact with it and makes it burn quicker as if by the effect of a draught. If only one of the carbons is oscillating, it is seen to be more brilliant, and wastes away more rapidly; then an unevenness supervenes, and the lamp ceases to work with regularity. It is for this reason that I make use of two contacts, and that I place the two carbons in identical positions. I have drawn a very important practical conclusion from it. Notwithstanding the perfection that the manufacture of carbons has reached, it is impossible that those that are coupled can have so absolute an identity as to burn together at the same level for a length of one meter for fourteen hours. This never happens, and there is no hope that it ever will. Now,

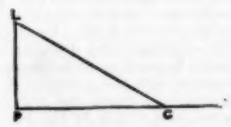


FIG. 6.

by a proper regulation of the springs which limit the oscillation, it is easy to lessen the movement of the carbon which is getting ahead, and even to fix it. This operation can be performed from time to time, without stopping the working of the lamps, and after that there is nothing to limit the length of the candles. Such are the advantages of my oscillating lamps: (1) utilization of a portion of the wires formerly unemployed; (2) utilization of a portion of the electricity hitherto lost; (3) increase of light through the

latter cause, and through the quickening of combustion; (4) equalization of the waste of the two carbons by regulation of the oscillatory motion. Figure 5 shows an arrangement having the same advantages as the preceding. It has been already stated that the wires were coiled in a gutter, C D E. The latter may be made of thin annealed sheet iron. The two outside edges are magnetized and form two straight longitudinal poles, the character of whose magnetism changes with every reversal of the current. The two contacts, C C' and E E' are attracted and draw back the levers C' and E', and the latter separate the carbons by means of small hooks fixed to their extremities. This arrangement, which is simpler than the former, resolves the same problem. Finally, the iron gutter may be so arranged as to have the poles on the inner side; and then, by covering the carbon with nickel, a magnetic substance, they are attracted and separated during the passage of the current without the need of any mechanical intervention. But in the latter case, of course, the cost of the carbon is increased. It only remains to add a few words on the quality of the light given by this burner. If it is operating points downward, it naturally illuminates from above downward—an excellent condition. The intensity of the light produced varies with the inclination. Vertical it has little intensity; but increases in proportion as the angle of the emitted ray diminishes; it is maximum at 60 degrees, and afterwards continually decreases till the inclination becomes null. These variations depend on the apparent extent of the carbon surfaces illuminated; and from this results the unexpected condition that if the light is at L (Fig. 6), the illumination of a horizontal surface, P C, is constant up to 50 degrees, the increase of distance being compensated by the increase of intensity. Thus, a round table illuminated by a burner, L, is lighted equally at every point. The flame thus produced is enveloped by a convex arc below, very fixed and steady, and accompanied by little noise if the speed is slow. When the apparatus is inverted so as to bring the points upward, there is a curious transformation of the light. The points are enveloped in an ascending orange-colored flame having the appearance of a butterfly of gas, and which, spreading itself out, fills the space included between the two branches of the gutter. The light is no longer a point, but a broad surface, which is violet below, red in the middle and toward the upper part, and from which the dazzling points of the carbon are distinguished like two brilliant stars. In order to explain the dilatation of the light and the resulting orange color, we must recall the fact that in a vacuum the carbons are disintegrated into very thin particles, which are soon sprinkled over the sides of the electric egg. It is this disintegrated carbon, which, driven off by the directing circuit, takes fire in the air and produces a flame. It must be added that, in this case, the repulsion which is periodically exerted on the flame increases the sound of the machine to such a degree as to render the burner annoying in a room; but it is the true burner for the street, where noises are attended with no inconvenience.

Preparations are being made to exhibit M. Jamin's lamp, in a few days, in an extensive laboratory at Paris.

LIGHT FROM THERMO-ELECTRICITY.

M. CLAMOND appears to have overcome the difficulty of producing a battery of this nature fit to produce the electric light. It is formed of iron as the electro-positive element, and of an alloy of antimony and zinc for the negative. They are arranged in a circular form, heated in the interior. The latest form consists of a number of pieces of cast iron, named the *collector*, so arranged that heated air can circulate between them. A large surface is thus exposed to the heat, which the iron collects and communicates to the couples. The *diffuser* is the outside of the apparatus, and is made of sheets of metal. The thermopile itself is placed between these two, and is so arranged that the junctions of the metals are alternately at the temperature of the collector and of the diffuser. The pattern now in use for lighting a workshop in Paris is 2½ meters high, and 1 meter in diameter. Another model, made for the exhibition at the Albert Hall, is square and smaller, though of the same power. Each half of the cylindrical battery can be made to supply a powerful electric light, while the square one can produce four lights of half the brilliancy. The electromotive force is, according to prolonged experiments, 218 volts, about equal to 120 Bunsen cells, while the resistance is only 0·31 ohm. The large battery consumes 9 or 10 kilogrammes of coke an hour; the smaller, about 6½ kilogrammes. The large external surface of the apparatus, radiating its heat to the air around, fits it for warming purposes as well as for lighting.

SPONGY IRON AND ANIMAL CHARCOAL AS AGENTS FOR THE PURIFICATION OF WATER.

By DR. L. LEWIN.

A PERFECT filtering material should be able to remove not merely suspended bodies, but such as are in states of physical and chemical combination, and either retain them in such a manner that the subsequent application of pure, or at least purer, waters may be unable to wash them out, or else to transform them into a condition in which they can no longer interfere with the quality of the water. In addition a filter must retain these powers unimpaired for a length of time. The attempts which have been made to imitate the processes of nature by passing the river water used for the supply of large towns through deep beds of sand and gravel have shown that such a process has no claim to be regarded as chemical. The case is different when charcoal, and especially animal charcoal, is used as filtering material. The latter not only holds back coloring matters and decomposes or partially retains most mineral salts and gases, but it absorbs and detains the most varied organic compounds, nitrogenous as well as non-nitrogenous. Particularly important is its power—first demonstrated by Claude Bernard, and confirmed by other inquirers—of absorbing albumen, a power which increases with the quantity of the latter, with the time of contact, and with the concentration of the liquid to be filtered, and which is the more important, as the arrested body is held so firmly as not to be removed by solvents. This valuable material has also its shortcomings, which especially consist in its ready saturation with impurities so that it needs to be revived, *i. e.*, freed from the detained matters; or if this is impracticable, to be renewed altogether. Other substances have therefore been suggested as substitutes for charcoal, and amongst others various modifications of iron, especially spongy iron. The latter substance has been submitted by the author to an elaborate experimental examination. His experiments show that as regards nitrogenous substances the spongy iron filter is inactive. Such substances are neither decomposed nor held back in such a manner as not to be readily washed out again. It can be stated with the fullest certainty that if only 10 c.c. of urine containing moving bacteria are mixed with 2 liters of water, and passed through the spongy iron filter, numerous bacteria can be detected in the filtrate. The odor of putrescent matter is but very slightly removed by spongy iron. The alleged improvement undergone by plumbiferous waters in contact with spongy iron were found to be insignificant.—*Zeitschrift fur Biologie*, 1878.

[Continued from SUPPLEMENT No. 188, page 2994.]

PROGRESS OF INDUSTRIAL CHEMISTRY.

BRIEF REVIEW OF THE MOST IMPORTANT CHANGES IN THE INDUSTRIAL APPLICATIONS OF CHEMISTRY WITHIN THE LAST FEW YEARS.

By J. W. MALLET.

HEAVY CHEMICAL MANUFACTURES—ACIDS, ALKALIES, AND MATERIALS IMMEDIATELY CONNECTED THEREWITH.

Sulphur.—By far the largest supplies of native sulphur still come from Sicily, although recent surveys of the volcanic region from whence the supplies are drawn render it improbable that the approach to monopoly which the island has long enjoyed can for many years, say for half a century, be maintained. Of late years the Romagna has added a respectable quota to the Italian supply, and several smaller deposits, as in Galicia, Spain, and Egypt, have been worked; but the great field presented in Iceland, of which highly favorable reports have been made, and which has recently, and more than once in the past, been entered upon, has not yet been made practically important. For the future chemical industry of the United States, the deposits at present known which are likely to become of great value are those of Nevada and the adjoining portions of California, the remarkable bed pierced by borings in Western Louisiana but still unworked, and perhaps the volcanic products of Hawaii and the Chilian Andes.

As regards the method of extraction of native sulphur from the gypsum and other earthy materials with which it is found associated, the simple process of piling up the "sulphur stone" in large heaps, arranged very much like those in which charcoal is burned, and melting out part of the sulphur by the heat produced in the smothered combustion of the remainder, is almost exclusively resorted to, and the scarcity of fuel in Southern Italy will probably always cause it to be there retained, in spite of the great loss of sulphur, of which at the best one-third is commonly destroyed or not made available in obtaining the remaining two-thirds. Attempts at less wasteful modes of treatment, as fusion in close vessels by means of high pressure steam, or solution by means of carbon di-sulphide, have made but little progress in the chief regions of production, mainly in consequence of the cost of fuel; the latter process, that by solution, is said to give very satisfactory results in Austrian Galicia. A simple observation made a few years ago by Sestini,* to the effect that somewhat above 400° C. calcium sulphate and sulphur react upon each other with evolution of sulphur dioxide,

$$CaSO_4 + S_2 = 2SO_2 + CaS,$$

indicates the importance, in the ordinary process, of keeping down the temperature of the heaps of sulphur stone, and this may perhaps serve to diminish the loss in the usual practice. The same precaution is indicated, however, with even greater urgency by recollection of the fact that at a temperature but little above its fusing point melted sulphur begins to thicken, its viscidity soon increasing so much as to greatly impede its draining away from the earthy impurities.

The consumption of sulphur, tending to rapid increase from the ever-growing manufacture of sulphuric acid, the extensive application of late years of sulphur and sulphur compounds to the prevention of grape disease in the vineyards of Europe, and other causes, has been largely economized by the introduction, in workable form and on no small scale, of processes for the artificial making or regeneration of sulphur from the "alkali waste" (calcium sulphide) of the soda manufacture. Of these processes those devised by Mond and Schaffner may be considered typical, both involving partial oxidation of the alkali waste by exposure to air containing carbon dioxide, under regulated conditions of temperature and amounts of air and water, thus producing thio-sulphate and poly-sulphides of calcium, followed by precipitation of sulphur from the mixed solution by hydrochloric acid, calcium chloride being the chief by-product. The final reaction under Mond's treatment seems to be mainly

$$CaS_2O_3 + 2CaS_2 + 6HCl = 3CaCl_2 + 3H_2O + S_{12} + 2,$$

while Schaffner aims at the result

$$CaS_2O_3 + 2HCl = CaCl_2 + H_2O + SO_2 + S,$$

the SO_2 being passed into fresh alkali waste lye in order to convert more calcium sulphide into thio-sulphate,

$$CaS + SO_2 + O = CaS_2O_3.$$

Other reactions, however, appear to take place to some extent under varying conditions, and it is desirable that in alkali works employing these processes for sulphur generation careful account should be kept of the yield actually obtained, and that this should be checked by frequent assays of the material used.

To a very limited, scarcely more than experimental, extent sulphur has been recovered from the Laming mixture for purifying coal gas,† essentially ferric hydrate, which, after use in removing sulphur from the gas, may by exposure to the atmosphere be restored to its original condition, with separation of free sulphur, which may be accumulated by repetition of the same steps. Much the greater part, however, of the coal used in making illuminating gas, and practically all that employed as fuel, is so treated as to involve the loss of the whole of the sulphur it contains. For the world at large it is not an excessive estimate to set down this as equal to one per cent. on 270,000,000 tons of coal annually, or 2,700,000 tons—more than seven times the whole sulphur product at present.

To this must be added a very large loss from the roasting of sulphurous metallic ores without utilization of the sulphur driven off. The production of sulphur as such from pyrites makes but little progress, and must be viewed as of very secondary importance, but the indirect economy resulting from the large scale on which pyrites is now used for making sulphuric acid is of the greatest value, and has served to prevent scarcity and rise of price of sulphur itself being, before now, sharply felt. The problem of the cheap and practically successful production of sulphur from gypsum remains in abeyance, and seems likely to remain so until the market conditions as to other sources of supply undergo notable change.

No remarkable departure has for some time been made from the established practice of sulphur refining, save that a few years ago the extensive use of flowers of sulphur in combating vine disease led to such regulation of the temperature of the distilling chambers as enabled a larger share than before of the product to be collected in this the sublimed form.

ACIDS.

Sulphuric Acid.—The scale upon which this fundamental reagent of the manufacturing chemist is made continues to increase, and there is observable an increasing tendency to connect its production with other industries, so as to secure, when not otherwise attainable, a saving of the heavy charges for transportation of so destructive a material.

It is but forty years since the first decided inducement to substitute pyrites for native sulphur in this manufacture was given by the threatened scarcity of the latter, due to the grant of a monopoly of Sicilian sulphur to a Marseilles house; but within this time, and especially the last few years, the extension of the use of pyrites has been so great that now seven or eight tons of acid are probably made from it for one made from free sulphur. This change has been partly aided by notable improvements in the kilns for burning pyrites, but largely also by the economy effected by metallurgic treatment of the burnt residue. Beginning with the saving of copper from cupriferous pyrites (like that so abundantly found in Spain and Portugal), too poor in this metal to be treated solely as one of its ores, by methods which have already been alluded to in this paper, means have since been found for obtaining also the relatively very minute quantities of silver and gold often found present, and still more recently the burning off of sulphur in the kilns has been so far improved that the residue of ferric oxide may be smelted into pig iron of very fair quality. Besides pyrites, the sulphides of lead, zinc, and other metals, and the sulphur of Laming's mixture from coal gas works, have been used, but to a very limited extent only.

As regards the mode of preparing and introducing into the apparatus the nitric acid vapor needed in the production of sulphuric acid, English and Continental practice differ in Europe; in France and Germany, liquid nitric acid, prepared by a separate distillation, is preferred, with a suitable drip contrivance for regulating its flow, while in England "niter pots" are in general use, heated by the gaseous current from the sulphur or pyrites burners, and adding to this current directly nitric acid vapor. It may seem worth considering whether such addition in the state of vapor might not better be made from small external stills of iron or stoneware, delivering their product into the rear part of the sulphur burner or into the flue leading therefrom, but heated separately, perhaps by steam jacketing of suitable temperature, and thus admitting of independent regulation of temperature.

With a view to determining the best shape and size for the leaden chambers, about which there is still much difference of opinion, it is greatly to be desired that systematic observations, and as far as opportunity may offer experiments, be made upon the scale of actual practice. In the working of the chambers, probably the most valuable novelty has been the introduction by Sprengel, instead of jets of steam, of cold water injected as spray by the aid of a little steam, thus enabling the supply of the necessary amount of water to be combined with the nice regulation of temperature.

Great interest attaches to the comparatively new "Glover tower" which is replacing the old form of de-nitrating tower of Gay Lussac's well-known contrivance for saving nitrous gases. In the original arrangement, the current of gases from the pyrites kilns often required to be cooled before reaching the leaden chambers or the de-nitrating tower, while in the latter the nitrous gases were liberated from the strong acid, brought from the absorbing tower, by means of steam or hot water, thus diluting this acid so far as to unfit it for immediate use again as absorbent. In the upper part of the Glover tower, weak acid from the leaden chambers and strong nitrated acid are allowed to mix, thus liberating the nitrous gases, while in the lower part of the same tower the acid encounters the hot gases from the pyrites kilns, and the transfer of heat from the latter to the former accomplishes the double purpose of cooling suitably the gases and concentrating the acid to such a strength that it can be used over again in the absorbing tower or utilized as part of the final product.

In the transfer of acid from place to place in the works improvements have been effected in the pumps, partly of stoneware capable of resisting the action of the acid, partly bringing to bear compressed air, so that the working parts need not be exposed to contact with the corrosive liquid. Not only in this relation, but in a multitude of chemical processes upon the large scale, the command of hard stoneware, cheap and withstanding well both high temperatures and energetic chemical reagents, is an advantage of the present day comparable with the improved glass and porcelain which our laboratories of research are so well provided with.

The least satisfactory feature of the great manufacture in question is perhaps the amount of niter still consumed, although this has been much reduced since the days that preceded Gay Lussac's improvements. The chief causes of the loss experienced are doubtless:

1. Gaseous compounds of nitrogen escaping at the final outlet or chimney, where theoretically nothing but atmospheric nitrogen in the free state should find exit, and this in spite of the use of a Gay Lussac's absorbing tower.

2. Nitrous compounds carried off in solution in the liquid acid made, this form of loss probably leading also to increased rate of destruction of the platinum stills for concentration, the metal of which is now known to be slowly but surely dissolved, apparently even by pure sulphuric acid.

3. Reduction of the other oxides or acids of nitrogen to the monoxide or even to elementary nitrogen, both incapable of performing the function of again taking up oxygen from the air. Such reduction, favored by too high a temperature, but liable to occur under conditions not yet, it would seem, fully understood, may take place in the leaden chambers, in the de-nitrating tower, or in the connecting flues back to the niter pots.

From the careful investigation of this question of niter consumption, immediately practical results, in the shape of reduced cost of acid production, may be looked for. We are

* Bull. de la Soc. Chim. de Paris, 24 (1875), p. 490.

† Sulphur from this source is more readily utilized in the manufacture of sulphuric acid.

still far from able to make oxygen on a sufficiently great scale, and at a low enough price, to admit of the pure gas being substituted for common air in the chambers, which might in that case be made closed, but it may be well to avoid laying aside this suggestion, long ago made, as involving a permanently impracticable idea.

For the concentration of the acid to full strength, although glass vessels are not out of use, those of platinum are of most importance, and in the form and arrangement of the latter sundry improvements have been devised, especially by the intelligent firm of Johnson, Matthey & Co., of London. Economy of platinum is secured to a valuable extent by the open pans of the precious metal, with capitals or hoods, connecting tubes, etc., of lead, which have recently been introduced in improved form by Faure & Kessler of Clermont-Ferrand.

In connection with the manufacture of sulphuric acid may be noticed with interest the quite recent production on an industrial scale and presentation in the market of sulphur trioxide or so-called anhydrous sulphuric acid, which replaces with advantage both the ordinary oil of vitriol and the Nordhausen or fuming acid for certain purposes, such as the production of the sulpho-acid-derivatives of benzene, toluene, anthracene, etc., employed in the manufacture of chemical dyestuffs. The trioxide is obtained by dripping common sulphuric acid into red hot retorts, thus breaking it up into water, oxygen, and sulphur dioxide, condensing the first of these, and causing the two latter to unite by passing them over platinized asbestos or similar porous material at a proper temperature. Both the solid trioxide, retaining but traces of the acid, and an oily, liquid, fuming sulphuric acid, holding 80 or 90 per cent. of trioxide, can now be had at very reasonable prices.

Nitric Acid.—There is little to note with reference to the production of this acid, except that sodium nitrate from Chili may be said to have for some years past become the universally employed material, and horizontal cast iron cylinders the apparatus generally used for the distillation. Slight modifications in detail of the condensing vessels are made from time to time.

Hydrochloric Acid.—This has long been essentially a secondary product of the alkali manufacture as conducted by the method of Leblanc, but the condensation of the acid has been much improved of late years, the first strong impulse in this direction having been given by the English "Alkali Act" of 1863, directed against the nuisance arising from destruction of vegetation by the acid gas when allowed to escape from the soda works. Since then increased supply of the liquid has conspired with increasing extent and variety of demand for it to still further improve the condensation, and like pains have been bestowed upon the same object in France and Germany. Sandstone or stoneware vessels for the strong acid, and coke towers for the weaker after products, constitute the apparatus used. A problem already of much importance and promising to become more important in the near future, is presented in the idea of making, by a cheap and simple process, hydrochloric acid (or chlorine) from the *calcium* and *magnesium* chlorides. The former of these is even now turned out as a waste product of several chemical industries on a very large scale, and from the extension of the ammonia-soda process and other sources vast additional quantities may hereafter be looked for. The latter—magnesium chloride—is available in large amount as a by-product of the treatment of the Stassfurt potash deposits. Solvay's recent proposal to treat these chlorides with silica or alumina can hardly be looked upon as a satisfactory solution of the problem, the temperature required being probably too high for economical results, and the utilization of the solid residues very doubtful.

Acetic Acid.—The two methods by which this acid is made—oxidation of alcohol and destructive distillation of woody fiber—remain without material change, the extent of the manufacture in both directions having, however, grown largely, mainly with the growth of dyeing and calico printing. The elaborate researches of Pasteur and others upon the phenomena of fermentation have had some little practical application to the work of the vinegar maker in directing the artificial *sowing* of the ferment organism, and in regulating the conditions for rapid and effectual conversion of the alcohol. The great extension of refined processes of organic chemistry, chiefly among manufacturers of the newer dyes, has produced a demand in the general market for "glacial" acetic acid, which is now made upon a pretty large scale, while but a few years ago it belonged solely to the domain of the scientific and pharmaceutical laboratory.

Oxalic Acid.—Dale's beautiful process for making this product from sawdust by heating with an alkaline hydrate has displaced all other methods. Founded on experiments of Gay Lussac, made half a century ago, the process was first given practically useful shape by Dale in 1856, was for a number of years altogether an English industry, but has of late been adopted also on the Continent of Europe. In Germany caustic potash alone is said to be used, but Dale's own method of working with a mixture of potash and soda (the latter by itself will not answer the purpose) seems distinctly the more advantageous, as allowing of the difficultly soluble sodium oxalate being in large measure purified by washing before it is decomposed by lime. An improvement is said to have been effected by washing the sawdust beforehand with a weak alkaline solution, thus removing incrusting matter and affording a nearer approach to pure cellulose to be fused with the potassium and sodium hydrates. Great increase of production and lowering of prices have followed the successful working of Dale's patent.

ALKALIES (CARBONATES AND HYDRATES.)

Potash.—Within the last twenty years the production of this alkali has undergone a complete revolution. The crude potash from leaching wood ashes, which formerly represented nearly the whole of the world's supply, has come in much diminished quantity from the forests of Russia, Canada, and the Northern United States, and has almost ceased to appear from several of the smaller regions of production—it now forms less than 40 per cent. of the general stock in market. Its place has been largely taken by a purer carbonate made, by Leblanc's classical process, from the sulphate of the newly discovered Stassfurt beds, and by like material derived from the ashes of beet-root molasses, and from the wash water used in cleansing sheep's wool.

In the manufacture of the first of these newer products there have been numerous, and in large measure successful attempts, to prepare the sulphate of potassium by crystallizing mixed solutions of the crude potassium chloride (carnallite) and magnesium sulphate (kieserite) found together in the great treasure house of saline material found overlying the rock salt of the Stassfurt region, but on the whole it seems to have proved more economical to act with sulphuric acid on potassium chloride, purified by previous crystallizations and washings, and thus to carry on the whole process as in the common soda manufacture. It is to this method that we must in all probability chiefly look to meet the future increase of demand for potash.

The second method, calcination of the residue from the stills in which the alcohol of beet root molasses has been driven off, has gained in importance of late years with the rapid increase of production of beet sugar, but the tendency now is, and most likely in the future will be, rather in the opposite direction, more of the crude residues being directly utilized as manure upon the beet crop itself, instead of, as formerly, being worked up into potash for sale. There have been one or two modifications of the method of treatment introduced of late, as the use by Camichel and Henriot of tanner's chestnut extract instead of sulphuric acid to acidify the diluted molasses in preparing it for fermentation, thus obtaining more potassium carbonate and less sulphate after calcination, and the system of C. Vincent of submitting the evaporated still residue to destructive distillation in closed retorts, with a view to utilizing the volatile products (ammonia, trimethylamine, etc.), instead of burning off the organic matter in open hearths.

The third of the newer sources of potash, the "suint" left on evaporation of wash water from wool factories, has also been employed in both ways, by distillation in retorts, utilizing the gaseous products for the illumination of the factories (original plan of Maumené and Rogelet), and by calcination in the air. The process seems to have yielded fairly profitable results, but has not established itself on such a scale as to utilize nearly all the washings of even the European wool manufacture. Its general importance is much less than that of the preceding methods.

Soda.—The recent history of the soda manufacture involves notice of improvement in the Leblanc process and of other methods which have been to some extent substituted for it.

1. *Modifications of the Leblanc Process.*—The first step as commonly carried out, decomposition of common salt by sulphuric acid, has been facilitated by the modern use of improved forms of the salt cake furnace, while no small success has attended the plan proposed by Hargreaves for avoiding the cost of making and using sulphuric acid, by passing a gaseous mixture of sulphur dioxide (from pyrites burners), steam, and air through a porous mass of salt heated in a special furnace to a temperature a little below redness. The soundness of the principle on which this method is based was long ago established, and of late the mechanical and other difficulties in detail of application have been so far overcome that salt cake is regularly made in this way on the large scale by a number of factories in England.

The second stage of the process, fusion of the sodium sulphate with coal and chalk, has been made to profit by two of the prominent features of improved furnace construction, the mechanical "black ball furnace" being heated by gaseous fuel on the Siemens principle and furnished with a revolving hearth, which enables the hand working of the contents to be dispensed with and excludes objectionable admission of air.

Fuel is economized by the employment of "regenerator" chambers and final use of the waste heat from the escaping gases to evaporate soda liquors from previous operations. At this stage of the chemical treatment Mactear's simple improvement may be noticed, consisting in keeping down the quantity of chalk to the strict demands of theory, and throwing into the hearth, after the reaction is over and just before drawing the charge, a small amount of quicklime, to be rapidly mixed with the mass by revolving the hearth again for a short time, this last addition serving the purpose, as an excess of calcium carbonate introduced at first had formerly but less advantageously done, of slaking on exposure to moisture, so as to disintegrate the lumps of black ball and fit them for rapid and effectual leaching.

There has been no recent change of first rate importance in the process of leaching, nor in the subsequent evaporation of the liquors and purification of the alkali; but the successful utilization of the insoluble residue of the leaching, the "tank waste," chiefly, as above noticed, for the recovery of sulphur, and to a subordinate extent for the production of sodium thio-sulphate and other purposes for which calcium sulphide may be used, has at the same time reduced the cost of alkali manufacture, and greatly mitigated, if not removed, a long complained of source of nuisance and inconvenience.

2. *Substitutes for the Leblanc Process.*—Of these, in the shape of experiments, and patented projects, there have been very many, but only two have established themselves in practical form.

The ammonia soda process, originally proposed some forty years ago, has but very lately been put into successful working shape by M. Solvay of Brussels. Starting with the same material as that of the Leblanc process, namely common salt, it treats it by an entirely different method, consisting essentially in absorbing gaseous ammonia by strong brine, passing in carbon dioxide under a pressure of about two atmospheres, preventing rise of temperature by special cooling arrangements, and so obtaining a deposit of difficultly soluble acid carbonate of sodium. This is separated, washed, and heated to produce the neutral carbonate, while the residual solution, holding ammonium chloride, is heated with lime to drive off ammonia as gas, which is employed in a repetition of the process. The carbon dioxide is obtained by lime burning with the aid of jets of steam. The intrinsic value of this method and the possibility of its completely replacing that of Leblanc have been much discussed. The latter is still in use for the production of much the larger part of the soda manufacture, while the newer process has proved its capability of at least competing therewith in the markets of the world, and is being extended to new factories, particularly in France.

The chief advantages of the ammonia process may be briefly stated as:

a. Great purity of product.
b. Diminished consumption of fuel.
c. Absence of all noxious escape of gases, either during the manufacture itself or from the waste products.
d. Reduction of loss from, at best imperfectly recovered, valuable material consumed (sulphuric acid of Leblanc process).
e. Possibility of utilizing salt in the form of strong brines, without requiring boiling down to solid salt.

The chief drawbacks of the process are the following:

a. Failure to make the chlorine of the salt available for industrial purposes, this assuming the, at present, useless form of calcium chloride. As has been above noticed, it would be of itself a most important achievement to devise a really workable method of making from this material hydrochloric acid, and hence chlorine and its various derivatives Such a method would vastly increase the chances of the ammonia process becoming *the* process for the manufacture of soda.

b. Sensible loss of ammonia—although theoretically the same ammonia may be used over and over again indefinitely, and although the loss in practice has been much reduced, it is still not inconsiderable, and hence the process is to a certain extent dependent upon the cost of ammonia, and the effect upon it of varying demand and supply. Improvement in this direction is possible and much to be desired.

c. Imperfect conversion into carbonate of the sodium chloride used. Quite a large part of the salt remains as such mixed with the calcium chloride in the waste residual liquor.

In any discussion of the relative merits of the two systems, the complicated and intricate relations of the by-products to other branches of chemical industry must not be overlooked. In proposing to replace a Leblanc factory by one working the ammonia-soda process, not only has the immediate cost of discarding old "plant" and substituting for it new to be faced, but also the complex and far-reaching commercial disturbance due to breaking up a system of combined manufacture of hydrochloric acid, bleaching powder, chlorate of potash, sulphuric acid, copper saving, etc.

The other partially successful substitute for the Leblanc process, namely, the production from cryolite of carbonate of soda, with alum, copperas, etc., as by-products, decomposing the cryolite in the first instance by treatment with lime at a low red heat, leaching the mass with water, precipitating the clear liquor with a stream of carbon dioxide, and evaporating the solution thus freed from aluminum as hydrate, has been worked for some years at Copenhagen, in Denmark, and Natrona, Pennsylvania. It furnishes soda of excellent quality, but the limited supply of cryolite, drawn from a single locality on the ice-bound coast of Greenland, must of itself continue to render the method one of merely subsidiary importance.

A change in the alkali manufacture which should not be left unnoticed is the production no longer of all the soda turned out, or nearly all, in the form of carbonate, a very large amount of the hydrate being now, and for a number of years past, also manufactured, chiefly for soap-boilers' use. Instead, moreover, of rendering caustic the finished carbonate, the crude liquors left after a single crystallization are worked up into caustic soda, which thus becomes an independent product of the factory.

Ammonia.—For several years past there has been large increase of demand not only for ammonium sulphate, but for caustic ammonia, growing out of the extending use of Carré's ice machines, the advance in refined chemical manufactures, as of organic dyestuffs, etc., and lately the introduction of the ammonia process for soda manufacture.

The staple, almost the only material used for obtaining ammonia, is still gas liquor, and the method of treating it has not recently undergone any very great change. Direct saturation of the liquor by an acid was long since given up, and distillation of the crude liquor, to which lime is added, usually by means of high-pressure steam, with or without the aid of air blown through the liquid, is practically always resorted to, the ammonia driven out being condensed in acid contained in a separate vessel, and for the most part so manufactured into sulphate; while for the production of caustic ammonia the gas, derived either from decomposition of a previously prepared ammoniacal salt or directly from the crude ammoniacal liquor, is carried into water in condensers presenting adequate surface. There have been a number of improvements in the details of the distilling and condensing apparatus, of which the most noteworthy involve the principle of so-called dephlegmation. A good example may be found in Solvay's recently invented form of apparatus for concentrating the ammoniacal liquor of the gas works.

Dr. Frank has not long since suggested the desirability of saving both the ammonia and the tar, which are at present lost upon a very large scale in the working of coke ovens; but, while admitting the magnitude of the loss now suffered and the importance of finding means for preventing it, the fact should not be overlooked that in all the processes of destructive distillation carried out on the large scale, it has been found very difficult to secure the best results at the same time as to the fixed and the volatile products, preserving meanwhile reasonable economy as to the form of apparatus, simplicity in the method, and amount of labor and time consumed.

The great problem of making ammonia synthetically from atmospheric nitrogen remains apparently as far as ever from an industrially available solution, but numerous attempts at such continue to appear in the form of an annually increasing number of patents.

FIBROUS ROCK-SALT.

(*Sodium Chloride.*)

THIS anomalous formation has always been an interesting one on account of the strong cubical "habit" of rock-salt, all other forms than that of a well-defined cube being rarities. The fibrous formation is not due to a crystallization of the sodium chloride in another system than the regular system, but is explained by an abnormal development of four cubical faces parallel to one axis, which may with propriety be called the prismatic axis. So far as I am aware, the formation of fibrous rock-salt has not been explained. Having the well-known fact before me, viz., "the influence exerted upon the crystal form of a body crystallizing out of its solution by the presence in that solution of a small quantity of a foreign body," I thought it probable that a similar effect might be produced upon the growth of sodium chloride crystals by the presence of a foreign body or bodies. In order to ascertain this I made a strong saturated solution of ordinary table-salt, filtered it, and precipitated out most of the salt by passing hydrochloric acid gas into the solution. The liquid was drained off from the precipitated salt, and allowed to evaporate *very slowly* for several days in a narrow necked flask, and then laid aside to cool. I then observed amongst the mass of ordinary salt numerous long well-developed prisms. Some of these prisms were an inch or more in length, and sometimes terminated by a broad cube. Others, again, were twinned according to the usual law, viz., "the twin plane a face of the octahedron." I observed that many of the cubical crystals were somewhat bent, and resembled closely the bent barytes crystals of the prism and basal terminal plane in combination. Nearly all the crystals (prismatic and cubical) were opaque or almost so, and of a very white color. In addition to free hydrochloric acid, I

found in the solution a quantity of magnesium sulphate and magnesium chloride, and it is to the peculiar retarding action of these substances, either together or singly, that I ascribe the general formation of fibrous rock-salt; for they could easily occur *naturally* in any rock-salt formation. As sulphate of magnesium and chloride of magnesium are constituents of sea-water, and generally present in all waters flowing from rocks, either crystalline or sedimentary, their presence during the deposition of rock-salt is insured, whilst the presence of hydrochloric acid would also be possible if a slight rise of temperature took place during the deposition, it being a fact that magnesium chloride gives off hydrochloric acid during evaporation at comparatively low temperatures.—*C. A. Burghardt.*

PETROLEUM AND ITS EXAMINATION.*

By A. BOURGOUGNON.

IN this communication to the American Chemical Society, I will describe the mode of examination which I have adopted in examining the different kinds of petroleum and its products. This method of analysis is the result of several years' experiments.

Before entering directly upon my subject, I think that a brief description of the general process employed in obtaining crude oil will be acceptable, and I will therefore relate some observations made during a recent trip through the oil-bearing territory.

I here take occasion to tender my thanks to Mr. J. Labouret, for his valuable information, and to A. J. Pouch, Esq., of the firm of J. A. Bostwick & Co., who has favored me with several samples very useful in my investigations.

Petroleum is found in several parts of the world, but the most abundant field of production is situated in Pennsylvania. It is also met with in several other States of the Union, but the Pennsylvania oil is justly considered the best in quality for illuminating purposes.

Contrarily to the rule governing the occurrence of most mineral substances, which are confined to well-determined geological formations, petroleum occurs in rocks of nearly all ages, from the Lower Silurian up; most abundantly in shales and sandstones; also, to some extent, in limestones. In the Rangoon and Caspian regions, the oil occurs near the surface in clayey soil, and collects in shallow pits. A noted locality is Ye-nan-gyoung, in Burmah, where the wells are narrow shafts, 180 to 300 feet deep, and large enough for a man to work in. In Persia, the oil is largely found at Baku, on the west shore of the Caspian; China yields a small amount of oil; Japan has small and undeveloped districts; New Zealand, also, shows indications. In the Caucasus, Russia, surface wells have long been worked, and lately wells have been sunk with success. In Galicia, Austria, are wells yielding largely; and Alsace and Hanover have produced some oil. Petroleum has likewise been found in Peru, Ecuador, Southern Mexico, San Domingo, Trinidad, and Nova Scotia, in small quantities. In Canada, petroleum occurs mainly in the corniferous limestone of the Lower Devonian, but is also found in greater or less quantity in the bird's-eye limestone of the Lower Silurian, and the Lower Helderberg limestone of the Upper Silurian.

In the United States, oil is very abundant in Western Pennsylvania, and has been found in considerable quantity in West Virginia, Ohio, Kentucky, and Tennessee. It has also been found in New York State, in Michigan, Indiana, Colorado, and California. The oil of Southern California comes from tertiary shales. The upper oil region of Pennsylvania begins in the vicinity of Tidioute; on the Alleghany, in Warren Co., and runs southwest of Titusville, thence nearly south, along Oil Creek, into Venango Co., to Oil City, and thence southwest to Franklin. The lower oil belt begins at Triangle City, Beaver Creek, Clarion Co., and runs southwest twenty-one miles to St. Joe, in Butler Co. In 1806, rock with some oil was struck at Brady's Bend, at a depth of 1,100 feet, giving rise to further investigation of the river above, which resulted in the discovery of a sand rock of 57 feet thickness at a depth of 960 feet, on the Alleghany River at Parker's Landing. The oil bearing rock of Pennsylvania is a sand rock, of which different strata are struck at different depths.

Various opinions have been advanced upon the origin of the formation of petroleum. It was almost generally admitted that petroleum was derived from vegetable or animal matter. Another explanation was that petroleum was of a similar formation to coal, but under a different condensation. Amongst the more recent explanations upon the formation of petroleum, it has been suggested that this hydrocarbon was produced by natural distillation of coals and bituminous shales. Lesquereux attributes its origin to the partial decomposition of low forms of marine vegetation, while Berthelot has advanced the theory that by complex chemical changes at present taking place in the interior of the earth, petroleum is continually set free.

Petroleum has been known for ages. The spring of Zante, one of the Ionian Islands, was mentioned by Herodotus more than two thousand years ago; and Pliny says that the oil of a spring at Agrigentum, Sicily, was used in lamps. The city of Genoa was formerly lighted from the wells of Amiano, in Parma, Italy.

Prof. A. E. Foote (*Am. Chem.*, Nov., 1872) states that Peter Kahn, in his "Travels in North America," published in 1772, gives a map of the Pennsylvania oil springs in 1771; but, according to H. E. Wringley, the earliest mention of petroleum in that State occurred in the report of the commander of Fort Duquesne, 1750, when he witnessed the ceremonies of the Seneca Indians on Oil Creek. A prominent feature of the ceremonies was the burning of the oil as it oozed from the ground.

In 1819, Dr. S. P. Hildreth, in the *American Journal of Science*, alluded to the discovery of petroleum in Ohio, on the little Muskingum River, and wrote: "It is beginning to be in demand for lamps in workshops and manufactories. It affords a clear, bright light when burnt in this way, and will be a valuable article for lighting the street lamps in the future cities of Ohio."

The oil spring of Cuba, Alleghany Co., N. Y., called the Seneca Oil Springs, was described by B. Silliman, in 1833, as a dirty pool, about 18 feet in diameter, covered with a film of oil, which was skimmed off from time to time for medicinal purposes.

In 1854, the Rock-oil Company was formed for the purpose of gathering oil in the vicinity of Oil Creek. The process employed by this company was to collect all the surface oil they could by means of cloths, which were subsequently squeezed into tanks. In 1858, Col. E. L. Drake, the superintendent of the Rock-oil Co., conceived the idea of boring an artesian well near Oil Creek. After several experiments conducted with the persistency and enthusiasm of discoverers, he, at last, in 1859, struck oil. A wild excitement prevailed throughout the country and almost everybody was stricken with the "oil fever;" companies were formed to bore for petroleum, and in New York alone, 317 of these companies were formed, representing a capital of more than two hundred millions of dollars.

Petroleum is extracted from bored wells of a variable depth, and about 7 inches diameter. Wells can be classified as follows: Flowing wells, pumping wells, gas wells, salt-water wells, and dry holes.

The commercial history of petroleum begins with the Drake well, bored in 1859, near Titusville. At a depth of 60 feet only, oil was struck, and the daily production was 25 barrels.

The first flowing well was situated on the McEllenny or Funk farm. Oil flowed in June, 1861, at the rate of 250 barrels a day for fifteen months and then stopped. Other flowing wells were bored, and amongst them the following are remembered: The Phillips well, on the Tar farm, with a daily production of 2,000 barrels; the Empire well, daily production 4,000 barrels for nearly a year, and then dropped to a pumping well, yielding 100 barrels a day; the Sherman well flowed 1,500 barrels daily for several months, when it declined to 700 barrels, and continued flowing for twenty-three months; the Coquette, well-known as the "glory of the oil region," manifested a surprising peculiarity—after flowing 600 barrels a day for several months, it suddenly increased its yield with great rapidity, and reached 2,000 barrels per day.

Flowing wells, like the above, are not now to be found through the oil region, but intermittent wells are sometimes bored. They flow at regular intervals, between which they are pumped.

Pumping wells are worked by steam engines, and the crude oil is received in a wooden tank. When this tank is full, it is gauged, and its contents are transferred by means of iron pipes into large iron tanks. These large tanks are the property of the pipe companies, who buy all the production of the country. From their tanks the pipe companies send the oil to their stations on the railroads through iron pipes, two or three inches in diameter, and from these stations petroleum is delivered into iron cars of a cylindrical form, holding about 85 barrels.

Throughout the oil district, 42 gallons are equivalent to 1 barrel, but the pipe companies take 43 gallons for the barrel, this extra gallon covering their charges for removing the oil from the tanks of the producer into their own.

The market oil delivered for a cargo is, therefore, not produced from a single well, but is the production of a whole district. Before the establishment of the pipe companies, the producers were obliged to send the oil to the railroad stations; now they are relieved of their trouble, since the pipe companies take oil directly from their wells, and pay for it prices fixed at the Petroleum Exchanges. Wells are bored by contract for so much a foot, but there is no external indication to prefer one place to another, although experiment has shown that the petroliferous zone follows a line having an inclination of 22° from north to south. This inclination is not always correct, since producing wells have been bored out of the 22° line, some time as far as 16° inclination, and other wells bored in the neighborhood, or even upon the 22° line, have proved to be dry holes. The yield of a well decreases sometimes very rapidly, and the general belief is that the well is obstructed by solid hydrocarbons, such as paraffine.

In order to remove this obstruction, a torpedo of dynamite is generally exploded in the well, which is intended to break the walls of the natural petroleum reservoir, thus connecting the shaft with it. The cost of such a torpedo is very high, and some producers try to dissolve the solid hydrocarbons by means of benzine. About 50 barrels of benzine are poured into the well, and after a lapse of twelve hours they are removed by pumping. In several instances, the benzine only dissolved paraffine, and the produce pumped as crude oil was merely a solution of paraffine in benzine. The use of the torpedo is not always followed by success. I was shown a well at Summit, the daily production of which had been 60 barrels, but its owner not being satisfied (a neighboring well yielding 100 barrels daily), resolved to have a torpedo exploded in his well. The result was that the daily production was reduced to 16 barrels. The average depth of producing wells is about 1,200 feet, and petroleum is designated under the name of third or fourth sand, according to the stratum where it comes from. This denomination is derived from the fact that before reaching the rocks bearing oil, the following layers are to be bored: 1st—The earth surface; 2d—First layers of slate rock; 3d—First sand rock; 4th—Second slate rock; 5th—Second sand rock; 6th—Third slate rock; 7th—Third sand rock; 8th—Fourth slate rock; 9th—Fourth sand rock. The color of the third sand oil is darker than that of the fourth, and the specific gravity heavier by about one decree Baumé. At Butler, crude oil is amber colored, and comes from the fourth sand. The cost of a derrick and the boring of a well is about twelve hundred dollars.

In these last years, the oil known under the name of Parker's oil has been in general demand abroad, as furnishing, when refined, a better quality burning oil than other crude oils. The fact, however, is, that other oils may yield just as good products as Parker's oil, but their treatment is more expensive.

It is estimated that the Parker district covers about 750 square miles.

Parker's oil is pumped to the following stations:

Harrisville,	Monterey Station,
Fullerton Station,	Sarah Furnace,
Foxburg "	Brady's Bend,
Parker "	Sligo.

Parker's oil is generally clear. At Butler, it is amber colored, but the color is darker in Millerstown; darker yet in Petrolia, Karns, and Parker; and the oil from Foxburg has no longer the reddish tinge of the oil from the above mentioned localities.

Although the denomination of Parker's Landing oil is generally adopted, we must remark that in the revised rules of the N. Y. Produce Exchange, the word Parker does not appear; it is, however, understood that when a contract calls for Parker's oil, the oil delivered must be of the first quality.

The examination of American petroleum by Pelouze and Cahours has established the existence of a series of hydrocarbons homologous to marsh gas. All these hydrocarbons are acted upon by chlorine, which produces a successive elimination of hydrogen, under the form of hydrochloric acid, and the substitution of an equivalent quantity of chlorine. The first term of the substitution for each of these hydrocarbons is represented by the chlorhydric ether of the corresponding alcohol. All these chlorhydric ethers, heated with sodium, give sodium chloride and a hydrocarbon containing two atoms less of hydrogen than the primitive hydrocarbon, thus converting the original marsh-gas series into the corresponding olefines. The hydrocarbons isolated and studied by Pelouze and Cahours are the following:

HYDROCARBONS.	FORMULA.	BOILING POINT.	SPECIFIC GRAVITY	
			LIQUID.	VAPOR
Butyl hydride....	C_8H_{10}	0°C.	0.600	
Amyl "	$C_{10}H_{12}$	30°	0.628	2.557
Caproyl "	$C_{12}H_{14}$	68°	0.669	3.055
Oenanthyl "	$C_{14}H_{16}$	92°–94°	0.699	3.600
Capryl "	$C_{16}H_{18}$	116°–118°	0.726	4.010
Pelargyl "	$C_{18}H_{20}$	136°–138°	0.741	4.541
Ratyl "	$C_{20}H_{22}$	158°–162°	0.757	5.040
Undecyl "	$C_{22}H_{24}$	180°–182°	0.766	5.458
Lauryl "	$C_{24}H_{26}$	198°–200°	0.778	5.972
Conicyl "	$C_{26}H_{28}$	216°–220°	0.796	6.569
Myristyl "	$C_{28}H_{30}$	236°–240°	0.809	7.019
Benyl "	$C_{30}H_{32}$	258°–262°	0.825	7.526
Palmityl "	$C_{32}H_{34}$	280°		8.078

It seems probable that, when petroleum is dissociated by heat, the products of the distillation must belong to another series than the marsh-gas. I have already begun the examination of the products of dissociation of petroleum, and I hope I will be able, before long, to bring my results before the American Chemical Society. For the present I will only state that I have observed the phenomena of fluorescence in several liquid hydrocarbons, resulting from the destructive distillation of petroleum.

I let here follow a table containing valuable information about petroleum from different localities, taken from A. Wurtz's *Dictionnaire de Chimie:*

Origin.	Heavy oil Virginia.	Light oil Pennsylvania.	Heavy oil Penn.	Parma.	Java.	Pechelbron.	Gabian.	Hanover.	Gallicia.	Circassia.	Bernlania.	China.	Canonsea.	Heavy oil of coal.
Volatile products at 100°C	1.0	4.3	.....	1.1	1.0	.....	.....	0.5	2.1	3.3	.....	.....	.....	.....
" 140°	1.3	10.0	.....	33.3	.....	.....	.....	3.0	8.7	15.7	4.9	1.0	2.7	.....
" 180°	12.0	28.7	.....	60.5	7.7	7.8	.....	.....	14.3	24.0	5.8	30.0	13.3	.....
" 200°	.....	31.0	.....	69.3	15.0	15.2	.....	11.0	21.7	27.7	.....	35.0	.....	12.9
" 220°	.....	.....	.....	.....	22.3	25.7	.....	14.0	25.3	32.7	8.0	45.0	19.0	.....
" 260°	.....	.....	.....	.....	30.0	40 5	.....	20.0	33.0	38.0	14.0	70.0	29.3	.....
" 290°	.....	.....	12.0	.....	.....	.....	.....	0.5	.....	.....	.....	.....	36.0	.....
Specific gravity at 0°C.	0.878	0.816	0.896	0.786	0.923	0.899	0.894	0.902	0.870	0.867	.....	0 880	0.884	1.044
" 50°C.	0.853	0.794	0.853	0.747	0.880	0.857	0.851	0.860	0.836	0.850	.....	0.822	0.854	1.007
Co-efficient of expansion	0.00072	0.00084	0.00073	0.00106	0.000769	0.000790	0.000807	0.000778	0.000813	0.000750	0.000774	0.000824	0.000794	0.000743
Composition: Carbon	85.3	83.0	84.9	84.0	86.2	85.7	85.1	80.4	82.2	84.2	83.8	83.3	86.3	92.0
Composition: Hydrogen	13.9	14.6	13.7	13.4	12.2	12.0	12.7	13.7	13.1	12.4	12.7	12.9	13.6	7 6
Composition: Oxygen	0.8	2.2	1.4	1.8	1.6	2.3	1.2	4.9	4.7	3.4	3.5	3.8	0.1	10 4
Heat of Combustion	10780	9903	10072	10121	10831	10089	.....	.....	10005	.....	.....	.....	11469	8916

Important information is derived from this table, as it furnishes the coefficient of expansion of petroleum, and the knowledge of this coefficient determines the empty space which must be allowed in the vessel containing the oil. This space will be:

V. K. 50.

V represents the volume of the oil; K, the coefficient of expansion; and, at the same time, we base our calculation on the assumption that the oil is to be submitted to a change of temperature of 50° C.

The coefficient of expansion of Pennsylvania crude oil varies from 0·00072 to 0·00086, according to the amount of naphtha contained in the oil. These coefficients, therefore, bear a certain relation to the gravity of the crude oil, and for the products of distillation the following numbers can be generally adopted with satisfactory results:

Under 0·700,	gravity at 15° C.	=	0·00090.
Above 0·700 to 0·750,	"	"	= 0·00085.
" 0·750 " 0·800,	"	"	= 0·00080.
" 0·800 " 0·815,	"	"	= 0·00070.
" 0·815,	"	"	= 0·00065.

In the above table of Wurtz, the numbers representing the percentage of oxygen in the composition of petroleum are apparently too large, since the fact that crude oil generally contains sulphur is not taken into consideration. In Canada oil the amount of sulphur is large, but in Pennsylvania petroleum I have detected only traces of this substance.

PETROLEUM OR CRUDE OIL.

Petroleum has been classified as follows, according to quality:

First Class.—The production of Butler, Clarion, Arm-

* Read before the American Chemical Society, June, 1879.

strong, and Venango Counties, Pennsylvania (excepting Bullion District).

Second Class.—The production of Warren, Tidioute, Fagundas, and Garland Districts, Pennsylvania.

Third Class.—The production of Bullion District of Venango County, the Bradford District, of McKean County, Pennsylvania, and the Limestone District of Cattaraugus County, New York.

Inspectors appointed to examine petroleum must employ all the means they possess for the determination whether an oil really is within the contract of sale.

A fractional distillation in ten parts is generally considered an examination of petroleum. This process is short, but the results are far from being satisfactory, and it is for this reason that we have entirely rejected it, and have adopted instead the *fractional distillation in one hundred parts.* The advantages gained are the following: 1. Exact determination in volumes and weights of the different products, as naphtha, benzine, burning oil, and residuum. 2. The determination of the presence of paraffine oil as soon as it appears in the products of distillation. Paraffine oil is always present in the distillate when the first products of decomposition are observed.

When petroleum is heated, one part of it will distill, and if the distillation is fractioned into one hundred parts, the specific gravity of each hundredth is always increasing until the hydrocarbons remaining in the retort reach a temperature at which they cannot exist; at this moment, therefore, decomposition occurs, and the result is a deposit of carbon and paraffine in the retort; also, gases escape, and a decrease in the specific gravity of the distilled liquid is observed.

This phenomenon of decomposition can be explained in the following way: According to the hypothesis of R. Pictet, temperature is the measure of the amplitude of calorific motion, *i. e.*, the amplitude of motion increases directly with the temperature. At first, the amplitude of motion produces merely distillation; but, in continuing the distillation, a point is reached where the hydrocarbons remaining in the retort reach a temperature at which they cannot exist without undergoing a partial decomposition, although this temperature is not high enough to produce ebullition. In short, the hydrocarbons $C_n H_{2n+2}$, are decomposed before reaching their point of ebullition. The products of decomposition are substances of lower gravity and boiling point; therefore, instead of an increase, a decrease of specific gravity, as well as temperature, is observed. The decrease in the temperature also shows that the dissociation has been accompanied by an absorption of heat.

The point where dissociation occurs during the distillation of petroleum is of importance for the refiner, for, from this point until the end of the distillation, paraffine is deposited in the retort, and the last portions of the distillation give only paraffine oil, which is not fit for illuminating purposes. Burning oil need not, however, be entirely free from paraffine. It is, to the contrary, in the interest of the refiner to employ as much as he can of this product, but he must always bear in mind that paraffine oil decreases the illuminating power of the burning oil.

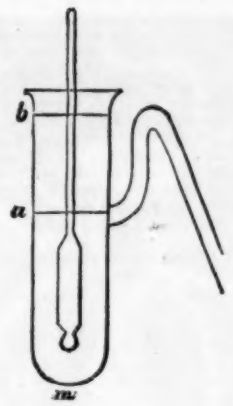
During the distillation, a thermometer must be placed in the retort to show at any moment the temperature of the vapors, as this observation of temperature is very important. A certain relation exists between the temperature at which a product distills and its specific gravity. When a sample of pure petroleum is distilled in one hundred parts, the temperature at which each hundredth distills follows an arithmetical progression, as also do the densities of each hundredth. The temperature, when distillation commences, varies; but, with an increase of 2° C., we also note an increase of specific gravity of $\frac{3}{1000}$. This increase of temperature and specific gravity begins only when the lighter products have distilled, and ceases with the appearance of the first products of decomposition.

One of the greatest advantages of the fractional distillation in one hundred parts, is a positive knowledge acquired upon the purity of the sample submitted to examination. If, during the distillation, before the appearance of the products of destructive distillation, when the temperature has reached about 320° C., the distillation is stopped, the specific gravity of the remaining oil in the retort must agree with its theoretical specific gravity. If, between the observed specific gravity and the theoretical specific gravity, there should exist a noted difference; and, on the other hand, if, during the first part of the distillation, the densities and temperatures had not followed a regular progression, the conclusion is, that the petroleum under examination is not pure, and will interfere seriously with the interest of the refiner. I should observe, however, that even for a pure sample of petroleum, the theoretical and observed specific gravities always differ slightly, since, during the first part of the distillation, a certain amount of uncondensable gas escapes, and cannot be taken into consideration for the calculation of the theoretical specific gravity.

During the distillation, the appearance of the distillate must be carefully noted, the most important being the color of the products distilled, and also the temperature when paraffine oil commences to solidify, by cooling with cold water. But not only the point of solidification need be observed, but also the temperature at which the oil loses its transparency. The fluorescent appearance of the distillates should likewise be noted. The last products of distillation show generally a blue fluorescence; should, however, a green fluorescence be observed, the sample of petroleum is suspicious, as I observed that this is found in petroleum to which residuum of former distillation had been added.

In order to save time during the distillation, I use the following apparatus, in which the product of the whole distillation is allowed to pass into or through the same vessel. This glass vessel contains exactly 20 c.c. from *m* to *a*, and 10 c. c. from *a* to *b*; this part is connected with a siphon of a special form which, when in action, each time removes 10 c.c. or 1 volume. *a m* is filled with 2 volumes, having a density, *d*, giving a weight, 2*d*. 1 volume, or 10 c.c., is received from the worm, having a weight or density, δ_1, which is found from the whole specific gravity, D, by the use of the following calculation. The glass contains $2d+\delta_1$, having a density $\frac{2d+\delta_1}{3}=D$. The density, D, is given by a densimeter plunging in the glass vessel. The density, δ_1, is evidently $\delta_1=3D-2d$; it remains in the glass, 2 volumes having a weight, 2D; another volume, δ_2, is received, and when the siphon is filled it contains 3 volumes, having a density $\frac{2D+\delta_2}{3}=D_1$, whence $\delta_2=3D_1-2D$. The densities, δ_3, $\delta_4-\delta_3$, are obtained in the same way. The siphon discharges the liquid in a vessel containing a densimeter, indicating the specific gravity of the distillate. For a receiver divided in 10 c.c., as described above, the quantity of petroleum to be distilled is 1 kilogramme.

An analysis of petroleum, conducted as above described, is not yet complete for the purposes of a refiner, it being necessary to add a lamp assay to determine the hourly consumption, and a photometric assay to determine the illuminating power of the burning oil. In order to make these two determinations, the distillate forming the burning oil is refined, as in the factories, by means of sulphuric acid, caustic soda, and washing with cold water. When the water is separated from the oil, it is now ready for the determination of its flashing and burning point, and also for the lamp and photometric assay. The results of the analysis may be tabulated, as we have done in a former communication to the American Chemical Society, but it is more convenient to



adopt a graphical method to represent the results. Upon the line of the abscisses the volumes are inscribed, and on the ordinates the specific gravities and corresponding temperatures, from which the curve of temperature and the curve of specific gravity are obtained.

Before distilling the sample of petroleum, it must be submitted to preliminary examinations; the first thing to ascertain is its specific gravity; the color and smell are noted. A thin layer of about two millimeters thickness is poured on a plate and left undisturbed for twelve hours, when it must not have any trace of soft or solid matter, but must remain fluid. A small quantity, about 100 c.c. of the sample, is placed in a platinum dish and ignited. Pure petroleum treated in this way will burn almost entirely, leaving a residue having a weight not exceeding 1 per cent. of the crude oil used. This residue is composed partly of oxide of iron. Before, however, weighing the platinum dish, it must be heated to completely burn the carbon deposited on its sides during the burning of the petroleum. For the distillation of petroleum I have adopted a copper retort, holding 2½ liters. A glass retort can be employed, but as crude oil contains generally some water, the glass is in danger, and severe accidents may result. It has been claimed that a glass retort offered the advantage that the distillation of paraffine oil could be observed. This assertion I doubt, and maintain that to make a distillation of petroleum in a copper still furnished with a thermometer, is more accurate to indicate the presence of paraffine oil, and is, at the same time, perfectly safe for the operator.

NAPHTHA.

In the Proceedings of the American Chemical Society, Vol. I., p. 119, I have described a process for the determination of naphtha in crude oil. Two kinds of naphtha are in the market: crude naphtha or "distillate," and deodorized naphtha. Deodorized naphtha is generally asked for. Naphtha shall be colorless and sweet (deodorized), and of gravity of from 68° to 73° Baumé.

Naphtha must not contain any oil; placed upon white paper, it must entirely evaporate, without leaving any greasy stain. A small quantity rubbed between the hands must evaporate quickly and leave the hands dry. To see if naphtha has been well washed, a small quantity is treated by diluted sulphuric acid in a bottle and agitated; the acid and naphtha must remain colorless. If naphtha of a very light gravity is asked for, it is important to ascertain that it does not contain relatively heavy products; the only way to prove this is distillation, where, however, only the specific gravities of the last products are observed.

REFINED PETROLEUM.

According to the rules regulating the petroleum trade, refined petroleum shall be standard white, or better, with a fire test of 110° Fahrenheit, or upwards. After having verified these points, the inspector must satisfy himself that the oil is not acid, and does not contain too large a proportion of heavy oil.

Recently complaints were received from Germany about the quality of the kerosene received. It was stated that the burning oil received at Bremen was not well refined, and was often acid. During the discussion of the reclamations of the German merchants, it has been advanced that kerosene could not be acid, for if sulphuric acid had been present, the kerosene should have shown a dark color.

That sulphuric acid produces a dark color with burning oil is a well known fact; but it must be remembered that in the action of sulphuric acid upon kerosene, when the sludge acid is produced, sulphuric acid is decomposed and produces sulphurous acid. Besides, the acid used for refining is not chemically pure, and generally contains oxides of nitrogen. From these remarks it follows that if sulphuric acid is not present in burning oil, this substance may contain either sulphurous acid or oxides of nitrogen, if the acid treatment has not been followed by washing with alkali, and finally water.

To examine for these acids, we treat the kerosene with an alcoholic solution of caustic soda. After separating this solution, it is evaporated, and the residue examined.

To ascertain if the kerosene contains too large proportions of heavy or paraffine oil, it is cooled down and the temperature at which the paraffine begins to solidify is observed. It is evident that kerosene must remain fluid at the winter temperature of the place where it is stored.

A very good way of ascertaining if kerosene has been well refined, is to submit it to a photometric assay.

First, a sample of about two liters is obtained and divided into two parts. The first sample is submitted to the lamp assay and to the photometric assay, then the second sample is refined by treatment with sulphuric acid, caustic soda, and water. If the result given by the photometric assay of the second sample corresponds with the result obtained by the first sample, the kerosene examined was well refined. Heavy oils in kerosene decrease its illuminating power. If a sample of kerosene, after being well refined, has an illuminating power below a standard admitted, it will be safe to conclude that the decrease of brilliancy in the light is due to the presence of heavy oils. If, during the lamp assay, which furnishes the hourly consumption of kerosene, and enables us to compare the price of kerosene with the price of other kinds of lights, the wick of the lamp gives off fumes and turns black by carbonization during the burning of the last parts of oil, this is an indication that the kerosene was not well refined, and was, perhaps, acid.

I have lately examined several samples of kerosene of the largest refineries of New York, and I did not meet with a single sample containing acids. The process of washing kerosene with water and testing the washings with litmus paper, must not be relied upon, as often blue litmus paper is too alkaline to indicate small quantities of acid.

Kerosene must stand a fire test of 110° Fahrenheit. It has been often pointed out that the fire test of kerosene is of little importance, for the real danger in the handling of oil is at the point where it gives off an explosive vapor. The French law requires that kerosene must not give off an inflammable vapor at a temperature of 35° C.

Several kinds of apparatus have been devised for the determination of the flash test and fire test of burning oil. The most reliable is an open vessel containing the oil to be tested; the inflammation is produced by an electric spark.

RESIDUUM.

The residuum must be free from coke, liquid at ordinary temperature, and must not contain any burning oil. In foreign countries the residue is free of duty, provided it does not contain any burning oil, otherwise the duty will be the same as for crude oil. The instrument used in America for ascertaining the gravity of petroleum and its products is the hydrominor areometer of Baumé. On the continent densimeters are generally substituted, and very often discussions arise about the gravity of petroleum, for the tables comparing degrees Baumé and the density are not alike. I think that the areometer of Baumé must not be entirely discarded, because the numbers indicating the gravity are smaller and more readily remembered than the numbers given by the densimeter. The construction of the densimeter is far more difficult than that of the hydrometer; their stems may be divided so as to indicate specific gravities directly; for this purpose, if we denote by *w* the weight of the densimeter, by *v* the volume of the liquid displaced, and by *d* its density, we shall have

$$w = d.\ v,$$

as the equation which will enable us to calculate the volume displaced for any corresponding density, and allow us to graduate the stem accordingly. This equation is that of the hyperbola; if, therefore, the specific gravities be supposed to vary by equal differences, the corresponding volumes will vary unequally, or the stem must not be divided into equal parts, but into intervals proportionate to the difference of consecutive ordinates of the hyperbola. Such densimeters are consequently of rather difficult construction, and require skill and intelligence on the part of the manufacturer. In a former communication to the American Chemical Society, I have given the formula to be employed to transform the degrees of Baumé's hydrominor areometer into corresponding specific gravities. (Proceedings of the American Chemical Society, Vol. I., p. 45.)

The formula referred to is

$$\frac{144{,}329}{134{,}329+N}=D,$$

in which N=degree Baumé, and D=sp. gr.

N	D	N	D	N	D	N	D	N	D
10	1,000	24	.911	38	.837	52	.774	66	.720
11	0.993	25	.905	39	.832	53	.770	67	.716
12	.986	26	.900	40	.827	54	.766	68	.713
13	.979	27	.894	41	.823	55	.762	69	.709
14	.973	28	.888	42	.818	56	.758	70	.706
15	.966	29	.883	43	.813	57	.754	71	.702
16	.960	30	.878	44	.809	58	.750	72	.699
17	.953	31	.872	45	.804	59	.746	73	.696
18	.947	32	.867	46	.800	60	.742	74	.693
19	.941	33	.862	47	.796	61	.738	75	.689
20	.935	34	.857	48	.791	62	.733	76	.686
21	.929	35	.852	49	.787	63	.731	77	.683
22	.923	36	.847	50	.783	64	.727	78	.679
23	.917	37	.842	51	.778	65	.724	79	.676

Volume of the areometer at +15° C.=144,329.

A fractional distillation of a sample of petroleum, taken by myself from a well at Millerstown, Pa., gave the following results. This well, called the "Great Leather," is 1430 feet deep; once in an hour it flows during ten minutes, and is then pumped. Daily production 200 barrels. Temperature of the oil taken directly from the well=10° C., specific gravity at +15° C.=0·790.

DISTILLATION.

	Gravity.		Gravity.		Gravity.		Gravity.		Gravity.
1	.662	21	.730	41	.768	61	.807	81	.807
2	.665	22	.733	42	.770	62	.809	82	.812
3	.668	23	.735	43	.772	63	.810	83	.812
4	.670	24	.737	44	.774	64	.812	84	.812
5	.676	25	.739	45	.775	65	.815	85	.813
6	.681	26	.741	46	.777	66	.817	86	.811
7	.686	27	.744	47	.779	67	.817	87	.810
8	.690	28	.746	48	.782	68	.814	88	.809
9	.695	29	.748	49	.784	69	.819	89	.809
10	.699	30	.749	50	.787	70	.822	90	.810
11	.703	31	.750	51	.788	71	.822	91	
12	.706	32	.752	52	.790	72	.819	92	
13	.710	33	.754	53	.792	73	.814	93	
14	.713	34	.756	54	.794	74	.806	94	
15	.716	35	.758	55	.795	75	.803	95	
16	.718	36	.760	56	.797	76	.810	96	
17	.721	37	.761	57	.798	77	.810	97	Residuum.
18	.723	38	.763	58	.801	78	.811	98	
19	.726	39	.764	59	.803	79	.810	99	
20	.728	40	.766	60	.805	80	.805	100	

In concluding this communication, I must state that I have obtained valuable information from A. Wurtz's *Dictionnaire de Chimie;* also from a paper published by H. Cornwall, in the *Scientific Monthly;* from *Dana's Geology;* and from the Proceedings of the American Chemical Society.

SPECIFIC MAGNETISM OF IRON.

SPECIFIC magnetism of iron forms the subject of an essay by Dr. Auerbach, of Breslau. He shows that this is not without influence on the galvanic behavior of the metal. If a current be conducted through an iron wire, phenomena appear which do not concur with other metals. The following are some of the known facts:

1. The actual galvanic conductivity has been very variously stated, between 12·35 and 15·9 per cent.
2. Resistance increases with rise of temperature.
3. The heat generated by the current, by Joule's law, is 448·0 as against 478·9 for copper.
4. On closing the circuit, an extra current takes place in the opposite direction; on opening, in the same direction.
5. Longitudinal magnetization of iron influences its resistance.

In examining the last (5) phenomenon, the great difficulty was to exclude the influence of temperature. An adiathermanous magnetizing apparatus was made by winding the copper on a wide glass tube, into which a caoutchouc tube was introduced, with a smaller glass tube within it; the wire itself being wrapped in paper.

Special arrangements were made also to reduce the intensity of (4) the extra current.

These due precautions having been observed, a large transient diminution of resistance, and a smaller permanent diminution, were observed, the former amounting to 2 per cent.

[Continued from SUPPLEMENT, No. 203, page 3235.]

THE BEGINNINGS AND THE DEVELOPMENT OF LIFE.

By Prof. EDMOND PERRIER.

THE FRESH WATER HYDRA, AND THE ANIMAL INDIVIDUALITY.

THE researches of Trembley, published at Leyden in 1744, have rendered the fresh water Hydras celebrated. Beings which may be multiplied as much as we wish by cutting

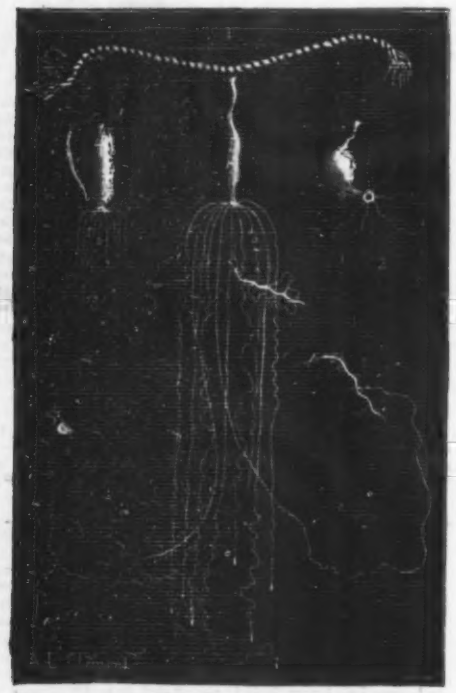


FIG. 1.—HYDRAS IN DIFFERENT STAGES OF CONTRACTION.

1. A Brown Hydra which has seized two Naiads and a Daphnia. 2. Another, half contracted and stuffed with food. 3. Gray Hydra, likewise digesting. (These two figures show well the difference in the length of the peduncles in the two species.) (Magnified about three diameters.)

them in pieces, and which live after having been turned inside out like a glove without appearing to have suffered the least damage from the operation, should by good right be regarded as new marvels. They furnish us in fact with valuable instruction.

The Polyps of our fresh waters were described for the time in 1703, in the Transactions of the Royal Society of London, by the illustrious Dutch micrographer, Leuwenhoek, and by an anonymous writer, each of whom had been able to obtain but a very small number of specimens. Bernard de Jussieu looked for and discovered them in the vicinity of Paris, where they abound, especially in the reservoirs of the Jardin des Plantes. He showed them to Réaumur, and there is a note of the fact in the preface to Vol. VI. of the "Memoires pour servir à l'Histoire des Insectes." It was only in 1740 that Trembley, a preceptor to the children of Count Bentinck, ignorant of former labors, began the study of the Polyps which he had discovered anew in the basins of the Chateau Sorguliet, the property of the Count in the vicinity of La Haye. These small beings of green color, almost always motionless on the plant that supports them, terminating in a crown of delicate filaments, variable in number and like branches or roots, appeared to him at first sight like plants. He soon saw them slowly moving in the liquid, stretching themselves out or contracting, and changing their location so as always to fasten themselves in the lightest part of the vessel which contained them. From this he was forced to ask himself if these were not animals. But he still had some doubts, and it was for the sake of clearing them up that he undertook the wonderful series of experiments which have made him the rival of Bonnet, his master, of Swammerdam, his contemporary, and of Lyonet, the able anatomist, who, in his enthusiasm for Trembley, learned to engrave so that he himself might execute the plates for the Memoirs on the Polyps.

The Hydras of our fresh waters number three species, which have been distinguished by Trembley: the Green Hydra (*Hydra viridis*), the Long-armed Hydra (Fig. 1, Nos. 1 and 2, and Fig. 2), or Brown Hydra (*Hydra fusca*), and the Gray Hydra (*H. vulgaris* or *grisea*), (Fig. 1, No. 2). All the forms have the general shape of a horn, the pointed end of which is provided with a sort of sucker, allowing the animal to fasten itself upon hard objects, while the opening of the horn is surmounted by the arms of the Polyp, which in number vary from six to eighteen. A membrane stretched between the arms closes this opening, although incompletely,

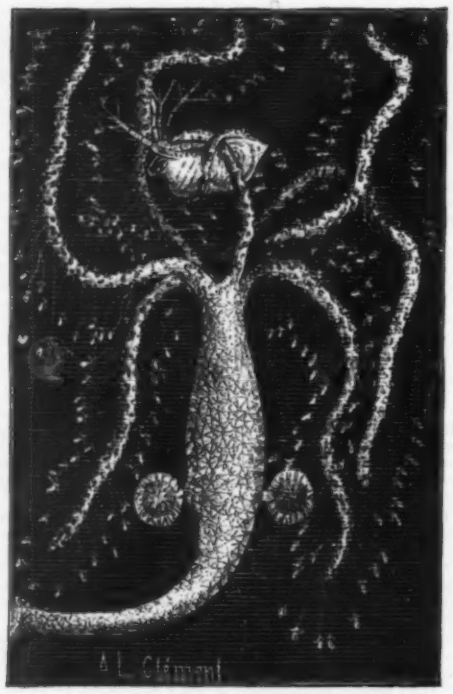


FIG. 2.—BROWN HYDRA,

Which has seized two Daphniæ; carrying two eggs; and surrounded by its large nematocysts (magnified 15 times). The vesicles of the nematocysts, which normally remain free in the tissues, are here figured free in order to show the general appearance of these organs.

for it is perforated in the center to allow the cavity of the horn to communicate with the exterior. This orifice serves both for the entrance of alimentary materials and for the issue of the residues from digestion. The arms usually have the appearance of very contractile delicate filaments, and possess the power of moving in all directions. In the Green Hydra their length never exceeds half that of the animal's body, but they may attain 2 inches in the Long-armed Hydra (Fig. 1, No. 1). They are sometimes as delicate as a spider's web, and constitute an apparatus for the seizure of prey. For the latter purpose, the animal extends them all around him, and keeps exploring the water, and unlucky the small animals which fall in their way. The prey seem to become at once paralyzed and remain sticking to the arms

FIG. 3.—LOCOMOTION OF HYDRAS.

1, 2, 3, 4. Hydra progressing after the manner of the "measuring worms." 5, 6, 7, 8, 9. Successive positions of a Hydra performing a somersault.

that they have touched. The latter at once infold them into the cavity of the Polyp. This manner of fishing seems at first sight identical with that which we have described as peculiar to the Rhizopods. We are tempted to liken the arms or tentacles of the Polyps to the protoplasmic filaments which constitute the pseudopodia of the lowest organisms, and which also are capable of arresting and suddenly paralyzing small animals. This resemblance is entirely superficial. In the Rhizopods the stupefying faculty resides in the very substance of the protoplasmic filaments; but the arms of the Hydras, on the contrary, offer very definite organs specially charged with the secretion of a poisonous substance and with the conveyance of it into the organism of the animals on which the Polyp seizes. These organs consist of numerous tough-walled vesicles (Fig. 2) filled with a hyaline liquid in which, when highly magnified, is observed a very fine thread coiled into a perfectly regular spiral. At the slightest contact this thread is thrown out like a spring, enters the tissues of the prey like a sting, and carries with it the poisonous liquid in which it was immersed and which covers its surface. These singular organs are called *nematocysts*, which recalls the fact that their essential parts are a thread and a vesicle. The Hydras and analogous animals are not the only ones that possess these. The *Actinias* or Sea Anemones, the Corals, the Madrepores, the floating Polyps known under the name of *Galeras*, etc., are all provided with them, and their action is often otherwise powerful. It is impossible to handle some of these animals without immediately feeling a violent burning followed by a somewhat pronounced inflammation, which often remains painful for quite a long time. The thousands of poisoned arrows which the Polyp shoots out from every side have of themselves alone caused those inflammatory phenomena so well known to fishermen; it is for this reason that the beautiful Anemones which abound on every shore, have, for a long time past, been called *sea nettles*. The most remarkable in this respect is the *Anthea cereus*, easily recognizable by its long green rosy pointed arms, which it is never able to draw entirely into the reddish brown sack that forms its body. The nematocysts of the fresh water Hydras are arranged in little groups forming quite regular spirals around the arms, and easily distinguishable with a strong lens. Each of these groups exhibits in its center one nematocyst larger than the others, and the spiral thread of which is armed at its slightly swollen base with three hooks bent backward, and which transform it into a sort of harpoon. It was formerly believed that these hooks were placed at the top of the thread, which remained embedded in the tissues while the poison vesicle was exserted. A figure, almost classical, and which we reproduce in order to put the reader on guard against it, represents a Hydra in which all the large nematocysts are reputed to be developed in that way (Fig. 2). It is just the contrary that takes place; but this figure has the merit at least of giving a good idea of the number and arrangement of these singular organs.

Suppress the arms of a Hydra, and make no account of the nematocysts, and there remains an organism which is not without real analogies with the *Olynthus*—the typical form of the sponges. In both cases the entire organism is reduced to a sort of sack, whose walls are formed of two superposed layers of cells separated by a less distinct layer,

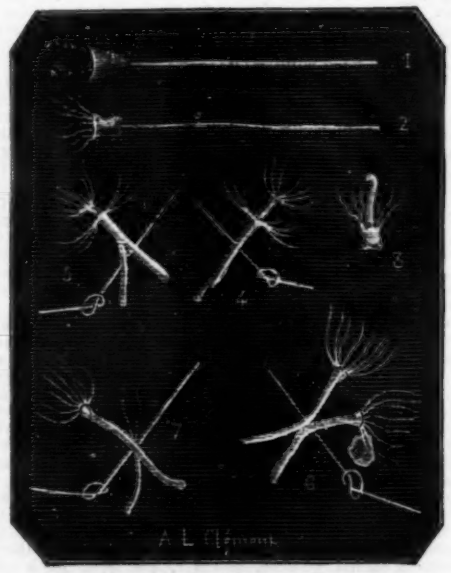


FIG. 4.—OPERATIONS ON HYDRAS.

1, 2, 3. Manner of turning a Hydra inside out. 4, 5, 6, 7. Two Polyps, one placed inside the other, in the process of separating. The outer Polyp splits in order to allow the inner one to escape. (Magnified 3 times.)

where are developed the spicules in the sponges and the contractile fibers in the Hydras. The interior of the sack is in both cases a digestive cavity. But, while in the Hydras this cavity communicates with the exterior only by a single orifice, serving at once as a mouth and an anus, we have seen in the sponges a number of pores serving for the entrance of water and alimentary matters (they might be considered as so many mouths), while a single orifice, the osculum, is alone charged with ridding the organism of excreta. The osculum, then, is physiologically an anus. It appears, however, that all the pores may close simultaneously in the *Olynthi*, under certain circumstances, so that in this case, save the arms, which may be wanting in certain Hydras (as *Protohydra Leuckarti*), and, save also the spicules and the nematocysts, the sponge exactly corresponds with the Hydra. The osculum, which serves both for the entrance and exit of water and food, is then comparable in all respects with the single orifice of the Hydras. From the standpoint of general structure, there is then a great analogy between *Olynthus*—the simplest form of sponges—and the common Hydra. These are, if I may so express myself, organisms of exactly the same order. Yet, if we did, in a former article, hesitate in defining what may be called an *individual* among sponges, and if the *Olynthus* itself, motionless, scarcely sensitive, without apparent will, could not be, without difficulty, distinguished from a true colony of Infusoria, it is not the same with regard to the Hydras. Here, animal life manifests itself in all its activity. Every Hydra shows itself clearly as a distinct individual, which wills, knows how to move with a distinct object in view, and co-ordinates its movements in such a way as to attain that object. This has been foreseen from what we have already said; but nothing demonstrates it better than an observation of the means employed by the Hydra to change its position. It is observed

(Fig. 3, Nos. 1 to 4) to bend its body like an arch, fix itself by the mouth, detach its base and bring it toward the mouth, then detach the latter, fix it anew, and bring toward it, as before, its posterior extremity; it progresses then exactly as do the "measuring worms," which appear to be measuring the ground over which they move. Nos. 1 to 4 of Fig. 3 represent the different positions assumed by a Hydra while thus progressing. But the animal sometimes moves in a more expeditious way. It takes its first step as before, fixes itself by the mouth, then arises vertically, bends its body over and fixes its foot and stands upright exactly like a gymnast performing a somersault (Fig. 3, Nos. 5 to 9). It is usually for reaching the light, which they are very fond of, although eyeless, that Hydras thus change their place; but they sometimes do so likewise to seek their prey. Differently from what we have observed in the sponges, everything here indicates a well-defined personality. Moreover, a more rigid comparison of these two sorts of organisms shows other important differences between them, proving that their origin cannot have been the same. We have seen that in the sponges the internal layer, which for short we will call the *endoderm*, differs essentially from the external one, which we may style the *exoderm*. The endoderms of sponges is formed of flagellate monads, the exoderm of amœbæ, and these two sets of organisms are already distinguished in the larva. The endoderm and exoderm of the Hydra, on the contrary, resemble each other almost perfectly. One of the most celebrated experiments of Trembley proves incontestably their essential identity. The exoderm of a Hydra may, at will, be made the endoderm, and *vice versa*. To do this it is only necessary to turn the double sack which forms the Polyp inside out. That the animal may continue to live it is necessary, then, that the exoderm which served as its skin, should betake itself to the digestion of food; and that its endoderm, which played the part of a digestive mucous membrane, should, on the contrary, become all at once the protective and sensitive part of the body. What more complete change could take place in an organism? It would seem that the Hydra ought to be killed outright by it. Such an operation, however, is attended by no harm to our singular animal. For a few hours the patient seems ill at ease; he even makes efforts (quite often successful) to recover his primitive condition. But if he does not succeed therein, he quickly puts up with his bad luck; and, at the end of two days at the most, he is seen to extend his arms in search of prey, and to eat voraciously—he is making up for lost time. The exoderm performs its new functions very well, and the endoderm, which is now the skin, is not at all behind it in this respect. Evidently nothing could better prove the essential identity of these two tissues than the facility with which one is transformed into the other. This operation of turning Hydras is performed without much trouble, and is deserving of being described in some detail. The Polyp is too small to be easily handled in its normal state. Before anything is done it is necessary to increase its size, to dilate its cavity as much as possible. The greediness of the animal makes this possible; for although he is perfectly contented with Infusoria or small crustaceans like Cyclops and Daphnes, he devours just as perfectly large Naiads or even the larvæ of insects. The red worms commonly sold at Paris for fish food suit him perfectly; these worms are the larvæ of a dipterous insect, *Chironome*. One of these larvæ, then, which is about as large as the Hydra, is given to the latter to eat. To swallow it the animal swells, as seen in Fig. 4, No. 1. The Hydra is then placed in the hollow of the left hand, along with a little water; then with a hog's bristle the bottom of the sack is slowly pushed inward. It sometimes happens that when a certain portion has been pushed in the animal in its movements turns suddenly back upon itself; if not, the pressure is continued in the sack until the latter has been completely reversed. This done, the animal is spitted near its mouth with a new bristle so as to prevent it from turning back again. In about two days the Hydra becomes completely used to the new order of things, and begins to eat again. From the success of this operation, must we conclude that the two layers of cells which form the essential part of the Hydra are, in a normal state, exactly identical with each other, and that their relative situation is of no importance to the animal? The contrary will appear probable if it be remembered that the Hydra is visibly sick for a certain length of time after being reversed, and that it makes efforts to regain its primitive position. But the reversed Hydra takes it upon itself to prove directly that the exoderm and endoderm do not, at the same time, possess identical properties. It frequently happens that a Hydra, after undergoing this operation, turns itself partially back again so as to exhibit the appearance shown in Fig. 3, No. 4. Under these conditions, the endoderm of the "*re-reversed*" portion is placed in immediate contact for a certain part of its extent with the endoderm of the reversed portion that it covers. It is not long before it becomes completely soldered with it. And further, the re-reversed portion forms at the upper part of the Polyp a sort of ligature which binds the upper orifice, brings all the parts derived from the old exoderm in contact, and these parts soon solder together in their turn. The result is, the mouth of the Polyp closes, and a new one forms at the extremity of the reflected part of the body. Here we see manifested a curious property of the Polyp tissue, that of welding together when brought into contact. However, in the case just mentioned, the welding takes place only between tissues of the same name—endoderm with endoderm, and exoderm with exoderm. Inversely, is the exodermic layer apt to weld with the endodermic, and *vice versa?* If these two layers are exactly of the same nature, this ought to be so. Another experiment will answer this.

It is possible to cause a Hydra to swallow another Hydra as large as itself. If the narrow extremity of the Polyp which is to swallow the other be clipped off with the scissors, the two animals may be arranged so that the inner Polyp will be exactly covered by the other as with a sleeve and extend beyond it only at the ends. It might be thought that, under these conditions, the inner Polyp would be digested or absorbed. But nothing of the kind takes place. Far from trying to devour one another, the two Polyps do all they can to rid themselves of each other; and they always succeed in quickly doing this if care has not been taken to keep them united by spitting them with a bristle as seen in Fig. 4, No. 4. Even in such a case they yet find means of separating, but at the cost of an operation which is terrible in appearance. Sometimes in front of, and sometimes back of the bristle, the outer Polyp splits (Fig. 4, Nos. 5 and 7); the slit soon extends throughout the whole length of the animal's body, and the inner Polyp finds himself at liberty. Then the outer Polyp closes, the two edges of the slit weld together, and each of the two patients resumes his ordinary life. Remark that in this experiment, the exoderm, the skin of the inner Polyp, is in contact with the endoderm or digestive layer of the outer one. These two parts have evidently manifested no aptitude for fusing. But let us make the experiment in another way: let us turn inside out the Polyp which is to be swallowed before introducing it into the digestive cavity of the other. The conditions are now changed; the inner and outer Polyps come in contact throughout the whole extent of their endoderm, and the result is entirely different. The Polyps this time do not separate, but in a few days both are found to be intimately welded together. They form a unique Polyp, scarcely distinguishable from ordinary Polyps except in the greater thickness of the walls and in the double crown of tentacles. The inner Polyp thereafter is alone charged with the functions of digestion, and it should be noted that it is by the aid of its old exoderm that it performs them.

The experiment might be varied by tying two Hydras together so as to keep them in contact by their exoderm, or else in reversing a Hydra and forcing it to immediately swallow a non-reversed Hydra. In this case it would be the two exoderms that touched each other, and what takes place when a Hydra is "re-reversed" in part, leaves no doubt as to the success of the experiment—the two Hydras would again weld together.

Thus, fusion in Hydras takes place only between tissues belonging to the same wall, internal or external, of the Polyp.

In these animals, then, there are normally two different tissues, one performing the functions of a skin, and the other of a digestive mucus, and each possessing special properties and characteristics. But from the fact that a simple reversing of the Hydra suffices to transform one into the other, it necessarily follows that these tissues keep their particular properties, not from a difference of origin or from some other more or less mysterious cause, but simply from a difference of position, from a difference in the reciprocal action and reaction of these tissues and of exterior environments; in other words, from a cause entirely physical. The Hydras show us with the utmost clearness what may be the influence of these environments upon organic tissues; and they show us that, placed outside of their normal conditions, these tissues do not die, but can be transformed in such a way as to live under new conditions which are made for them; and that to these new conditions they *adapt themselves*. Their physiological properties, their chemical composition, and their external form may thereafter become more or less deeply modified; and this is one of the most fecund sources of diversity of the animal kingdom.

But what is this faculty of adaptation of tissues itself, if not the faculty possessed by elementary living beings, unicellular organisms, of adapting themselves to the surroundings in which accident causes them to live?

[*To be continued.*]

COLOR BLINDNESS.

Mr. POLE, F.R.S., the well-known engineer, is afflicted with color blindness, but it was not until he was nearly thirty years of age he suspected his vision was defective. The suspicion once admitted was confirmed by further investigation, the result of which was a valuable paper recently read before the Royal Society. Professor Pole says:

"In the first place, we (persons who are 'color-blind') see white and black, and their intermediate or compound gray, provided they are free from alloy with other colors, precisely as others do. Secondly, there are two colors properly so called, namely, yellow and blue, which also, if unalloyed, we see, so far as can be ascertained, in the normal manner. But these two are the *two only* colors of which we have any sensation; and hence the defect has been given the scientific name of *dichromic vision*. But now comes the difficulty of the explanation. It may naturally be asked: 'Do we not *see* objects of other colors, such as roses, grass, violets, oranges, and so on? And if we do see them, what do they look like?' The answer is that we do see all such things, but that they do not give us the color sensations correctly belonging to them; their colors appear to us varieties of the other color sensations which we are able to receive.

"This will be best explained by examples. Take first the color red. A soldier's coat or a stick of red sealing-wax conveys to me a very positive sensation of color, by which I am perfectly able to identify, in a great number of instances, bodies of this hue. If, therefore, the investigation of my experience ended here, there would be no reason to consider me blind to red, or as having any grave defect in my vision regarding it. But when I examine more closely what I really do see, I am obliged to come to the conclusion that the sensation I perceive is not one that I can identify separately, but is simply a modification of one of my other sensations, namely, *yellow*. It is, in fact, a yellow shaded with black or gray—a darkened yellow, or what I may call yellow brown. I find that all the most common hues of red correspond with this description, and in proportion as they are more scarlet or more tending towards orange, the yellow I see is vivid. The explanation, I suppose, is that none of such reds are pure; they are combinations of red with yellow; so that I see the yellow element of the combination, while the true red element is invisible to me as a color, and acts only as a darkening shade. I obtain a further proof of this by the change of sensation when the hue of red is altered. I find that as the color approaches crimson the yellow element becomes fainter and the darkening shade more powerful, until very soon the yellow disappears, and nothing but a gray or colorless hue is presented to my eye, although the color is still a positive and powerful red to the normal-eyed. So that there is a hue of red which as a color is absolutely invisible to the color-blind.

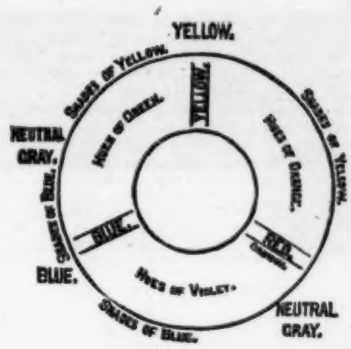
"If I go on beyond this point, and take reds that pass from crimson towards the hue called lake, I see my other color come in, a faint blue, which increases till violet is reached, when it becomes more decided. Violet is understood to be a compound of blue with red, and, accordingly, the red element being invisible to the color blind, violet hues generally appear to them only as darkened blue. There are, however, examples where, from the red being very strong, the blue appears to lose its effect, and the impression given is colorless, black, or gray. They correspond, in fact, with the neutral red before described, although still called purple by the normal-eyed. This latter effect is much enhanced under the artificial light of gas or candles. A similar explanation will apply to orange, a combination of red and yellow, in which the yellow only is perceived.

"The appearance of green to the color-blind corresponds exactly to that of red. Green in its true aspect is invisible to them, and consequently when neutral—*i.e.*, unmixed with any other color—it presents to their eyes the appearance of gray. When, however, it is mixed with yellow (and most of the greens in nature are yellow greens) they see the yellow only, but diluted or darkened by the invisible green element. And in the less frequent cases where the green is mixed with blue they see the blue only in like manner.

"It may now easily be understood how it is that so simple a defect of vision gives rise to so complex a series of symptoms as those already described. Take first the color red. If it is a scarlet variety, as the majority of reds are, presenting the appearance of yellow to the color blind, they may naturally confound it with the latter color, as well as with orange, with yellow green, and with brown, all which cause to them the same sensation. If, on the other hand, the red contains a preponderance of blue, it may be confounded, on the same principle, with blue or violet. If it is a neutral red, lying between the two, it will be confounded with black or gray. A pale pink, though very distinctly colored to the normal-eyed, often offers so little color to the color-blind as to be mistaken for white, or very light gray.

"The same explanation will apply to green. Its yellow varieties may be confounded with red, orange, yellow, and brown, its blue varieties with blue and violet, and its neutral hue with black or gray, or, if very pale, with white. The confusion of orange with yellow, and of violet with blue, black, and gray, have been already sufficiently explained."

The following diagram will assist the reader to comprehend Mr. Pole's remarks:



[The diagram represents a color-circle with yellow at the top, graduating from left to right through successive hues of orange to red; thence through crimson and successive hues of violet to blue, and through various hues of green to yellow. A person "color-blind" would see the yellow as yellow. Proceeding from left to right he would observe the same color growing darker and darker until he reached the *crimson*, which would appear to him as "neutral-gray." From that point he would see shades of blue becoming lighter until his eye had passed the true blue, as marked; the shades of blue would then begin to darken until he reached the point where he would see green as "neutral gray," and thence he would observe shades of yellow growing lighter until the pure yellow was again reached.]

"Statistics," says Mr. Pole, "go far to prove that color-blindness is very common; the number of persons color-blind in England—that is, given to mistake red for green, brown for green, purple for blue, and occasionally red for black, is probably not less *than one in fifty*, and including all kinds and degrees of color blindness, *one in twenty!*" This estimate is surely an exaggerated one, but be this as it may, wherever "color-blindness" exists it admits neither of cure nor amelioration. In all other respects the vision may be, as in Mr. Pole's case, exceptionally good. *Shades* of color may be readily recognized, and the perception of form perfect, but if the vision be *dichromic*, it will remain so to the end. No remedy is known, and from the nature of the case none is likely to be discovered. The only practical advice that can be offered to those who may become conscious of the defect is to seek employment in departments of business that do not make any demand upon the color-sense.

BROWN-SEQUARD'S THEORIES OF THE NERVOUS SYSTEM.

THIS eminent teacher continues to announce that his experiments and researches prove that the doctrines of cerebral localization are erroneous and based on false assumptions. His demonstrations are striking. Thus, in an animal in which the right motor half of the pons varolii was incompletely divided, the left half of the bulb was afterward cut through, there remained no other way of communication between the two halves of the encephalon than by a small portion of the anterior longitudinal mass of fibers on the right side of the protuberance. Now, in this case, the galvanization of the motor centers at the right and at the left caused exactly the same movements in the limbs of the side opposite to the centers. The experiment was repeated a number of times, always giving the same results.

It is observed by M. Grasset that the whole doctrine of Prof. Brown-Séquard is governed by two entirely new principles, viz.:

1. All the phenomena which one ascertains after limited experimental or clinical lesions of a part of the cerebrum are produced by action at a distance.

2. There are no agglomerated and circumscribed centers in the cerebrum for any function. There are certainly special cells, distinct elements, but these cells are distributed through the whole mass of the cerebrum. In other terms, there are no circumscribed, but diffuse centers.—*Med. and Surg. Reporter.*

GEOLOGY AND COAL PLANTS.

MR. RALPH LOUDON writes as follows to the *Colliery Guardian:* We cannot doubt that coal is formed of vegetable matter. This fact cannot on reasonable grounds be doubted, even if coal be carefully examined with the unassisted eye. We have no difficulty whatever in seeing that portions of it have a most remarkably distinct fibrous structure, resembling in some cases charred wood or charcoal. But when ground down into slices and examined by a good microscope, we no longer doubt its origin, and feel proud of our instruments which afford us such invaluable help.

Some coals are unquestionably composed wholly of huge plants, branches, and leaves of the various orders which wafted in the tiny breezes of their *once* tropical climate. Other coals, again, says Professor Huxley, "are principally composed of the minute globular 'seeds' or 'spores' of plants related to our living club mosses; and these may be regarded as being essentially of the same nature as the shales of Kettle Point, on Lake Huron."

It would be unwise of me here to enter into the many interesting discoveries so recently brought to light about coal;

but there are one or two points which bear so directly upon my query that I crave the assistance of some of your talented correspondents.

Not many months ago I was asked by a workman to go and see what he had found in the "bottom" (thill). On removing the newly-fired shot we found in the under-clay large roots passing through it. On examining the roof we saw indications of the same plant, seemingly as if left standing in a vertical position. We collected some of the best root specimens, and gave them a coat of shellac. Not many weeks after the longwall "packers" reached the plant in question by the driving of a "top caunch." Fully 8 feet of it was now exposed to view. I inclose a diagrammatic view of the coalseam, as seen in the working of the mine, viz., Heworth Colliery.

FIG. 1.

Fig. 1 (*a*) is the under-clay with the four roots passing through it, (*b*) the bed of coal ("Five Quarter"); (*c*) the roof of the coal, composed of shale, showing the upright trunk of a tree passing through it.

After much care and anxiety we managed to block down (in one piece) fully 25 inches of the beautiful specimen. On further examination we found a circular coal ring going round the outer circumference, having a thickness of about ¼ inch. This layer of coal seemed to incase the plant from the roof of coal probably to the apex of the trunk. At a little distance nearer the center was observed a second coal ring, having a thickness of ⅛ inch; diameter of trunk on the coal head, 15 inches.

Fig. 2 is a plan considerably enlarged from Fig. 1, showing the two coal rings. Reasoning from the facts in geology, we can observe how the under-clay acted the part of soil for the nourishment of our coal plants. Again, we doubt not that the coal seams were not only formed out of the remains of old vegetations, but that in some instances the plants actually grew in the spot where we now find the coal of our carboniferous formations; but it is far from uncommon to find the coal, or the beds immediately adjacent to it, penetrated by the trunks of trees still standing in an upright and vertical position. These are indubitable facts.

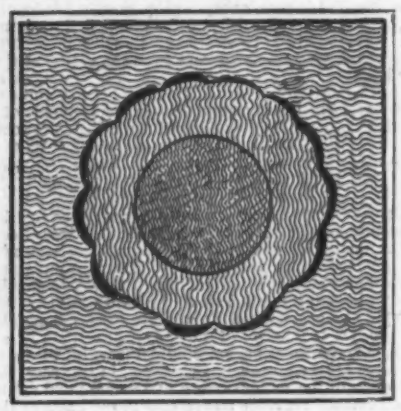


FIG. 2.

Now what I wish to ask is: If coal is the result of vegetable decay and chemical action, why is the plant in question an exception to the rule? Instead of being converted into coal, we find that this tree plant partakes of the nature of the shales surrounding it. On examining the more finely-powdered shale with the microscope, I found it to consist, generally, of mixed particles derived from vegetable and animal remains. The same mineral matter was seen in the washings of this tree plant. Some will readily conclude that this is entirely due to the chemical action of the shales when in a plastic condition. Grant this, which I have no objections in believing. But if coal rings be common in and surrounding the majority of such plants, how are we to reconcile one statement which seems to contradict the other? This is no vain assumption. Casual observers notice this. And even the more ignorant of our miners guard themselves against the "pitfalls" of these ancient geological plants.

The roots of the same plant are found to have a thin covering of coal. By following these "coal pikes," as the miners call them, you can invariably add to your cabinet of fossils perfect and undamaged specimens of these singular trees, which seem to have been the most gigantic of the primeval forests of the old world.

A BED of anthracite of excellent quality and well adapted for smelting has begun to be worked at Ching-man-chow, near Ichang, China. The coal district extends for 75 square miles, and has 10 beds, one of which, only 100 feet below the surface, is estimated to contain 1,200,000 tons. The region contains also valuable iron ore, and it is not improbable that an important iron industry will be established.

THE STATUE OF ARAGO.

A STATUE of François Arago, from the chisel of the sculptor Mercier, was unveiled on the 21st of September, at Perpignan, the city of the great physicist's birth. In giving our readers a representation of the eminent artist's work, we will also remind them of the principal events in the life of him whose memory it is to perpetuate. Dominique François Arago was born on the 25th of February, 1786, at Estegel, near Perpignan, and died at Paris, October 2, 1853. His father, who had occupied the post of cashier of the mint of Perpignan from the time of the Revolution, gave him a good education at the college of that city. At the age of seventeen, young François, after passing a brilliant examination, was admitted to the Polytechnic School. On leaving the latter he was attached to the Observatory as Secretary of the Bureau of Longitudes; and in 1806, the Emperor, on the recommendation of Monge, appointed him with Biot and two Spanish commissioners, Chaix and Rodriguez, to continue the work begun by Delambre and Méchain, of obtaining a more accurate measurement of an arc of the meridian to serve as a basis for the new metric system. The two French savants immediately applied themselves to the work, and established a great triangle designed to connect the Isle of Yvice (one of the Balearic Islands) with the coast of Spain. They pitched their tents at the apex of this triangle, that is, upon one of the highest mountains of Catalonia, in order to put themselves by means of signals in communication with Rodriguez, who was established on the mountain of Campney, in the Isle of Yvice. Here, in these rocky solitudes, exposed to all the inclemencies of the weather, they passed several winter months. "Often," says Biot, "the tempests carried away our tents and displaced our stations; but Arago, with indefatigable perseverance, immediately went about replacing them, and, to do this, allowing himself repose neither night nor day." On the outbreak of war, being employed on the island of Majorca, he was taken for a spy, saved from the mob by some months' confinement in a fortress, afterwards taken from an Algerian vessel by Spanish corsairs and harshly treated, shipwrecked on the coast of Sardinia, and after new perils, reached Algiers in a Bedouin disguise. Here he was treated with suspicion by a new dey, but finally reached Marseilles in a French frigate, in 1809. The Academy of Sciences, to reward him for his arduous labors, received him into membership, although he was only 23 years old and such a proceeding was contrary to its rules. Shortly afterwards he was appointed professor at the Polytechnic School. Here he taught analysis and geology for more than twenty years. In 1830 he became perpetual Secretary of the Academy of Science and director of the Observatory, a post which he retained till his death. In 1830, also, he became a politician, and entered the Chamber as Deputy from the eastern Pyrenees, and took his seat at the extreme left, between Lafitte and Dupont de l'Eure. Toward the end of his life Arago took an active part in the Revolution of 1848, espousing the cause of the people. A member of the provisional government and minister of war and of the navy, he was chosen by the Constituent Assembly as one of the Executive Commission. During the bloody days of June he marched to the barricades at the head of the troops and displayed great personal courage. He opposed the election of Louis Napoleon to the presidency, and gradually ceased to take part in public affairs. But to the last he proved true to his republican creed, and after the coup d'état of December, 1851, refused to take the oath to the Government of Louis Napoleon.

Notwithstanding his political activity, Arago never for a moment ceased to cultivate the sciences with wonderful ardor. His discoveries were numerous. He was the author of more than 60 distinct memoirs on various branches of science, and he did very much both by his lectures and writings to popularize science. He rendered special services to optics by his own experiments and by his influence over others, and especially by directing the labors of Fresnel and Malus. He was the first to recognize the value of Young's optical papers. He investigated magnetical phenomena, and made some contributions to meteorology especially in connection with electricity. He also successfully investigated the colors of polarized light, the application of polarization as a test of the origin of light, the experimental proof of the retardation of light in dense mediums, the apparent magnetism of copper rotating near a permanent magnet, and the influence of the aurora upon the needles.

His name will for ever remain as one of the scientific glories of France.

THE STATUE OF ARAGO, AT PERPIGNAN.

THE POMPEIIAN CENTENNIAL EXCAVATIONS.

THE opening ceremonial ended, a bell rang to summon people to the excavations. In different parts of the ninth region ten chambers were to be opened and their contents revealed, and there was an eager rush from all points. It is impossible to describe the intense expectation on every face as the first picks struck the ground, or the scene around each place to be excavated. Crowds were pressing round every opening. People were perched all along the tops of the broken walls, to the imminent peril of their limbs, and groups were thickly gathered along the higher unexcavated level, and on every other point of vantage. Each room to be excavated had been cleared of the upper falling in, leaving about four feet to be removed. The indications given by the preparatory work in one of the larger rooms having been particularly favorable, I took my station there, and witnessed in the course of three hours, as the various objects peeped forth from the scoriæ one by one and were taken up, such a revelation as I shall never forget. For the first five minutes there was a breathless silence as the men worked; then, as the scoriæ fell away, part of a green object became visible. In a moment the workmen's hands had cleared the space around it, and amid deafening cheers a small bronze horse, nine inches in length, was held aloft. Then a large amphora appeared; then two bronze vases, one with handles; then a large iron key, and as each in turn was lifted high for all to see, "*Bene, bene!*" burst in a chorus of hearty satisfaction from the people. A list, with the briefest description, of the things which then followed in rapid succession would fill a column. There were at least a dozen bronze vases of different shapes, sizes, and uses, with and without handles, and in one a number of bronze coins oxidized together, and many other coins were found at intervals during the excavation. There were many handsome bronze fibulæ, several bronze bracelets, a number of rings, many terra-cotta vases, tazze, and amphoræ, and a remarkable number of little terra-cotta water cups for bird cages, various kitchen utensils, a spit, forks and knives of iron, a bronze bottle, a number of little bronze bells, a dagger with ivory handle, a knife with ivory handle, a bronze casserole, and a terra-cotta money box. After these and many more objects, of which trayful after trayful was carried away, had been taken out, a mass of black material appeared, which, falling to pieces, proved on examination to be beans; then a quantity of millet and hemp seeds, with considerable remains of the sacks which had contained them, the carbonized wood of grain bins and of a barrel with iron hoops, and great masses of beams of the upper floor, sufficiently solid, but entirely carbonized like charcoal. Among these remains a splendid bronze candelabrum was come upon, but its tall, slender, fluted stem was broken. In short, from noon till three o'clock a continued succession of objects was revealed, almost more rapidly than I could note them down. The mere names and briefest memoranda filled sixteen pages in a large note book. Some of the rooms revealing nothing, others a few bronze and terra-cotta vessels; but in one room a skeleton was found, and in the smallest chamber opened four were discovered huddled together.—*London Times.*

SWEDEN imports annually about 1,000,000 tons of coal. The yield of the Swedish coal pits for 1876 was about 90,000 tons.